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THE AMERICAN ACADEMY OF CROWN AND BRIDGE PROSTHODONTICS

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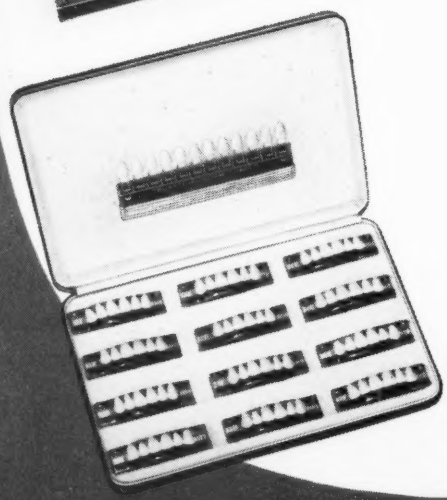

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THE JOURNAL OF PROSTHETIC DENTISTRY

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THROUGH THE EYES OF THE EDITOR

Charles H. Moses discusses the significance of some natural laws in the practice of preventive and restorative dentistry. The discussion is based upon Box's observations regarding periodontal disease. There can be little objection to the statement that periodontal disease is a result of combined systemic and local factors. The recommendation that cusps of deciduous teeth should be ground to tend to flatten them is open to question. There is little disagreement that vertical forces on either natural or artificial teeth are favorable while horizontal forces on either are unfavorable. There is some question about the claim that "Flat cusped teeth tend to translate the load vertically even when the direction of the mandibular movement is horizontal." The determination of the direction of the resultant forces is a complex problem which cannot be covered adequately by such a simple statement. Many factors are involved, such as the relative size of the jaws, the shape of the occlusal surfaces of the teeth, the kind of food being masticated, the habits of the individual, and the jaw position when the closing forces are applied. One factor which has not been given sufficient attention is that of the skill and muscle-tendon sense of the patient. This factor makes the successful use of dentures possible regardless of all other considerations. It can vary the resultant forces against the tissues to a very great degree.

The statements made regarding the grinding of cusps are based upon the way natural teeth wear (out). It seems illogical that the worn out patterns of occlusal surfaces of natural teeth should be the patterns for the occlusal surfaces of artificial teeth. The mechanics involved in the occlusal surfaces of cusp teeth passing over each other produce the typical worn occlusal surfaces. When this process is carried to the ultimate (an extreme anti-Monson pitch), a greater lateral force may be developed between the upper and lower teeth than with cusp teeth.

S. Howard Payne describes a method for combining the esthetic properties of copolymer resins and the accuracy of vulcanite. The method is simple and provides the additional advantage of the "double-vulcanization" technique. The warpage and shrinkage of the acrylic portion of the denture would tend to distort the vulcanite base, but it seems logical that the vulcanite base would resist this distortion to a certain extent also.

Carl Philip Regli and William L. Kydd report a preliminary study of the lateral deformation of metal base dentures as compared to the lateral deformation of plastic base dentures in function. While their tests were made with only one patient, the results indicate a possible influence toward greater ridge destruction by plastic dentures than by metal dentures. The lateral deformation of the lower plastic dentures was uniformly greater than that of metal dentures. This problem seems worthy of further investigation. It would be interesting to know the amount of deformation of an upper denture during mastication, and its effect upon occlusion.

E. D. Shooshan suggests the relining of

acrylic baseplates with cold cure acrylic to make them more accurate. It seems like a good idea.

F. A. Peyton, H. B. Shiere, and V. P. Delgado report their findings after comparing the various properties of heat-cured and cold-cured resins. They made the usual tests of physical properties on both kinds of resins as well as others which have a bearing on their practical use. They observed a similarity of most physical properties, but they conclude that the cold-cured resins are not superior to the heat-cured resins. In some ways, the heat-cured resins are better. They point out the need for certain modifications in the cold-cured resins and for changes in their processing techniques which would make them more satisfactory.

Hobart H. Proctor has described a method for characterizing denture base materials which seems to have certain advantages over other methods. The variations in color are made throughout the thickness of the flanges rather than being applied on the surface. The method allows the shaping of the flanges of the denture after it is processed without destroying the characterization. The added colors cannot be scrubbed away by the patient as he cleans his dentures. The procedure may not allow for as much flexibility in color placement, and it makes the contouring of the material at the gingival margins of the teeth more difficult than the method described by Pound (J. Pros. Den. **1**:98-111, 1951).

John L. Powers has described the simplest of all the techniques yet suggested for the characterization of denture bases. The colors are applied on the finished denture instead of being processed in the base itself. However, the method has two distinct disadvantages. First, it can be used only on dentures made from cross-linked resins. It will craze the usual acrylic denture base material. Second, the colors can be brushed off by the patients as they cleanse their dentures. Otherwise, the technique will produce a good result. If these disadvantages could be overcome, the artistic possibilities are unlimited.

Daniel J. Holland suggests a tantalum alveoplasty for patients who have severe undercuts on the labial side of the lower anterior ridge. This would seem to be a good method to eliminate the undercut, but it would have the disadvantage of causing an excess fullness in the lower part of the lower lip. Possibly better *esthetic* results could be achieved by surgical removal of the undercut.

Sylvester W. Cotter and Edward J. Budill compare the advantages and disadvantages of various anesthetic agents for the oral surgery for immediate dentures. Their conclusion is that Pentothal Sodium is the anesthesia of choice. Certainly intravenous anesthesia has the advantage of administration remote from the field of operation. While the choice of anesthetic agent must be the responsibility of the oral surgeon, the absence of balooning of tissues, and the fact that no nasal inhaler is needed make it easier to check the fit of a surgical template and the occlusion of the teeth when the immediate dentures are inserted.

Romie H. Miller describes two methods of adapting the Hanau Model H articulator for use in the treatment of temporomandibular joint disturbances. The instrument is modified so it has a variable intercondylar distance and a means for changing the relations of the casts without remounting. These adjustments are added in order to predetermine the occlusal relations of the teeth when the lower jaw is repositioned, and to make the instrument more adaptable to recorded relations. The suggested modifications are quite ingenious. We do question the advisability of attempts at gross repositioning of the mandible except where anterior tooth contacts alone have existed for a long period of time. Also we prefer an instrument for diagnostic purposes that does not have a solid hinge axis. Such an instrument is the Phillips Occlusoscope.

John B. Davis describes a technique which will simplify the boxing of hydrocolloid impressions. Only one possible difficulty suggests itself to us. The added wax may cause more displacement of reflected tissues than that which is normally produced by a stock tray.

William L. McCracken compares the problems involved in tooth-borne and tooth-tissue-borne partial dentures. He suggests variation in impression procedures, clasp design, and denture design according to the type of support of the denture. He concludes cor-

rectly that each type of denture requires a specific type of treatment.

L. F. Abel and R. S. Manly report on the masticating efficiency of partial denture patients. The tests were made for groups of patients who had different missing teeth restored, and who had different opposing dentitions. The efficiencies of each group were determined and compared with those of standard dentitions. The results seem to indicate that removable restorations are relatively inefficient, especially when they are opposed by complete dentures. Also, the increasing efficiency noted with the time the restorations are in use indicates that the skill (and possibly the habits) of the patient are an important factor in the successful use of dentures. While partial dentures may not improve the masticating efficiency of patients with opposing complete dentures, the partial denture restorations should be made to protect the supporting structures of the edentulous jaw from traumatogenic forces. We also question the use of 20 degree posterior teeth against natural teeth in young patients.

David Grosser compares the indications for precision attachments with those for clasps for the retention of partial dentures. He favors the use of precision attachments when only a few teeth remain. He makes use of splinting in these borderline situations. The splinting probably makes their successful use possible. The other indications he lists seem to be sound. He suggests the positioning of the male and female parts of the precision attachments so the denture is at least partially tissue-borne. This should help to protect the remaining teeth in all except rotational movements around the attachments when occlusal forces are applied.

Edwin S. Smyd discusses some of the auxiliaries in operative dentistry. He analyses the quality of light and lighting in a way to point out its importance and the reasons for its effects on the operator's efficiency. The little aids he suggests will be of value in every dental office. The discussion of the various cutting instruments and abrasives might be called "the mechanics of instrumentation," which means "use of the right instrument to do the job." Unfortunately, many dentists do not give sufficient thought to this phase of their practice.

John R. Bluff has described a simple restoration for anterior teeth which provides full coverage with the advantage of acrylic for esthetics and gold for strength. It seems to be usable in many situations.

Clarence H. Blanchard describes a method for removing undercuts from a refractory cast. It will require skill to do, but it can save the time required for producing a refractory cast from a master cast.

Miles R. Markley has written a good exposition of the facts about the compensation for the shrinkage of gold in dental castings. He compares the various methods of shrinkage compensation and describes a practical technique for making castings that fit. He emphasizes the importance of attention to detail in the procedure.

V. P. Delgado and F. A. Peyton report the variations in the amount of hygroscopic expansion of refractory investment which result from variations in the methods of handling the material. Mechanical spatulation and a room temperature water bath produce more expansion than hand spatulation and a mouth temperature water bath, while the addition of borax to the investment mix reduces the amount of expansion according to the concentration of the borax. This information will be of value to those who use a hygroscopic investment and procedure.

Edwin S. Smyd applies the science of physics to the laboratory procedures used in making gold inlays. He discusses the factors which affect the accuracy of castings in each of the various steps in the process for making indirect inlays. He favors the indirect method with hydrocolloid as the impression medium. Waxes, dies, investments, and investing procedures are discussed in a way which points out the variables and their control.

Clarence H. Blanchard describes an attachment to keep wax out of your bunsen burner. The flame will not blow out in a draft either.

—Carl O. Boucher

EDITORIAL

WELCOME

The Editorial Council and the Editor of THE JOURNAL OF PROSTHETIC DENTISTRY are proud to announce that The American Academy of Crown and Bridge Prosthodontics has joined the family of organizations which the JOURNAL serves. This newest addition to the list of organizations which supply material for THE JOURNAL OF PROSTHETIC DENTISTRY will bring to the readers of the JOURNAL the knowledge and experience of many respected dental educators in the field of fixed dental prosthesis.

The American Academy of Crown and Bridge Prosthodontics (see p. 297) is a comparatively young organization. Its members have earned recognition by dentistry as leaders in their special area of interest. Their willingness to impart their special training and experience to others is exemplified by their interest in having their scientific papers made available to all dentists.

The American Academy of Crown and Bridge Prosthodontics has selected Dr. Stanley D. Tylman to be the Associate Editor who will collect papers given before the Academy and screen them for publication in the JOURNAL. His experience in writing and editorial work will be of great assistance to the Editor. The material he submits to the Editor from the Academy will be of great value to the readers of the JOURNAL.

—Carl O. Boucher

THE AMERICAN ACADEMY OF CROWN AND BRIDGE PROSTHODONTICS

CLAUDE R. BAKER, B.A., M.S., D.D.S.

Chapel Hill, N. C.

IMMEDIATELY following World War II, a group of dentists whose major interest for some years had been crown and bridge prosthodontics found themselves consistently drawing together and repeatedly expressing the need for an organization as an instrument to fulfill their purpose—to achieve by mutual study and cooperative activity a high and ethical standard of practice, teaching, and research in the art and science of crown and bridge prosthodontics. Organizational meetings were held in a number of geographic locations throughout the country, and a charter membership evolved as an outgrowth of professional devotion, specific interest, and contribution to the field. Some thirty or more dentists actively participated in the organizational phases of the American Academy of Crown and Bridge Posthodontics. They elected forty-five men to charter membership. The first officers were: Claude R. Baker, President, L. Walter Brown, Jr., Vice-president, Robert P. Dressel, President-elect, George H. Moulton, Secretary, and E. C. Brooks, Treasurer. Two official annual meetings, including scientific programs, have been held to date.

A group with such a purpose requires a medium through which to disseminate its clinical developments and research findings if true professionalism is to be fulfilled. The American Academy of Crown and Bridge Prosthodontics is grateful for the opportunity to co-sponsor and contribute through THE JOURNAL OF PROSTHETIC DENTISTRY which, because of the expert guidance and sound judgment it has received on the part of the editorial staff, has won the respect of the profession. Stanley D. Tylman was elected to represent the Academy as an Associate Editor of the JOURNAL.

It is reasonable to expect specific clinical information and scientific development concerned with any one phase of dentistry to come, in part at least, from those organizational entities which take particular interest in that phase. The contributors to THE JOURNAL OF PROSTHETIC DENTISTRY complement their organizational purpose and give unselfishly of their information in order that the profession as a whole may profit. In function, the JOURNAL serves not only to disseminate but also to integrate knowledge in prosthodontics. Because of these factors, the American Academy of Crown and Bridge Prosthodontics is doubly proud and honored to participate and be represented in THE JOURNAL OF PROSTHETIC DENTISTRY.

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THE CONDITIONS OF SUCCESS

J. Leon Williams, D.D.S., L.D.S.

London, England

THERE ARE, in my opinion, but two general ideas or ideals of success, and they may be defined as being founded on the conception of power and the conception of acquisition. The highest form of success is synonymous with evolution, and evolution is development in power. This is the conception of success that has always been held by the world's greatest teachers, by those who believe that man is a creature of unmeasured and perhaps immeasurable possibilites. By processes of material and spiritual evolution man is becoming more and more the master of nature and of himself. Powers previously unsuspected are constantly appearing, and the development of every new power seems to supply the soil in which still higher faculties take root and grow in turn.

Editor's note.—The present trend is to measure success in dental practice in terms of dollars. This evaluation of success is far different from that of the dental leaders of the past whose names we all know and respect. We remember them and their work because of that extra service they rendered to their patients, and to us and our patients. Their work is our heritage, and our continuing progress is their continuing reward. The goals, ideals, and ethical principles so well expressed by Doctor J. Leon Williams were his own. We are profiting by what he did in many phases of dentistry and research. It is for these reasons that this article on practice management is being reprinted.

—C.O.B.

Success, therefore, in the broadest and best interpretation of the term, should be measured by the extent to which the individual, by his own volition and effort, is assisting the great inherent constructive powers of nature in his own evolution. But this, I fear, is not altogether the conception that the great majority of people have in mind when they talk or think about success. To *acquire* rather than to *develop* is the prevailing idea of success. To acquire money, friends, and popularity —that is the usual thought of what success means. The success of acquisition, of course, is perfectly legitimate, if one but maintains the right mental attitude toward it; in fact, it should always come, and always would come in a properly organized society, as the natural result or reward of the success of development or evolution. But that mental attitude is the all-important thing. It is what a man intends in his action that counts, so far as he is concerned.

Read before the New York Dental Society, Albany, N. Y., May 5, 1910.
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THE IDEAL OF SUCCESS

What, then, is to be our ideal of success? We must determine this before we can take the first step toward discussing the principles or elements of success. Let us try to get at the real heart of the matter. To the young man just entering our profession (and it is to him that this paper is chiefly addressed) the word "ethics," which is intimately associated with thoughts of success, is usually interpreted as a term of restraint, when it should connote freedom and liberty of the highest order. But the subject is not often presented so as to permit of such an interpretation. The sole aim of ethics is, or should be, the placing of a high estimate on the value of conduct, and by conduct I mean a man's whole attitude toward himself and his fellows. A man starts out in life with certain powers and accomplishments which he desires to dispose of to his fellows in return for certain benefits which they can bestow on him. A man is successful just to the extent to which he can materialize those powers and accomplishments, just to the extent to which he can convert them into something that will add to the comfort and happiness of his fellows; and ethics should teach him how this exchange can be brought about most effectively, how society may realize the full value of a man, and how a man may develop and express himself with the greatest freedom and liberty. It is my conviction, founded on the study and observation of many years, that the chief cause of human failure in any position in life is man's willingness to dispose of his powers and accomplishments at something below their real value—his willingness to sell himself too cheaply—and what I have to say in this paper will be said from *that point of view.* The *first* and most important element in all human success is to *believe* greatly—to believe in oneself, in one's destiny, and in the absolute benignity of the powers that control that destiny. If that belief, that faith, does not underlie all detail, then the detail is mere surface trumpery. A witty after-dinner speaker in London has just made the suggestion that what our weary, overworked, depressed world most needs is the appointment of official *encouragers*—men who shall go about quietly and endeavor to make people think more highly of themselves. There is a deep philosophy behind this pleasantry. To believe greatly is to will greatly, and to believe and to will greatly is to achieve greatly. The highest form of individual success is that in which work or calling reacts on life and character, ever stimulating further effort and higher evolution, and the material reward of such a life should always be sufficient and adequate.

ELEMENTS OF SUCCESS IN THE DENTAL CAREER

If you agree with my conception of what constitutes success, let us make application of the foregoing statement of general principles to our own occupation. Let us follow the career, step by step, of a man from the moment that he decides to become a member of our profession, and mark the influences and conditions—or, in the terms of my subject, the elements—out of which success may be constructed.

CONDITIONS FOR THE DENTAL STUDENT'S SUCCESS

Our hypothetical young man's chief asset at the commencement of his career will be his knowledge of all the details of our professional work and his power of

making practical application of that knowledge. This asset bears about the same relation to professional success that capital and credit do to mercantile success. It is, therefore, highly important that the value of this asset should be raised to the highest possible degree. It is thought to be in the nature of a commonplace or platitude to say that the first and most important condition of success in any calling lies in the detailed knowledge that a man has of that calling, but I am sure very few young men realize the full significance and meaning of that commonplace expression, for the simple reason that its full meaning is anything but commonplace. In its broadest interpretation it involves the deepest problem of our material and possibly of all higher existence—the problem of the acquisition of power over our own organism and over our materials, and the latter may almost be said to be involved in the former. In the very forefront of the conditions necessary for acquiring power over our own organism must be placed determination or will, a quality capable of infinite or at least of indefinite extension. There, again, we seem to be uttering a commonplace, and again I must insist that these commonplaces contain the deepest philosophy of life and have become commonplace only because they are spoken without thought. Let our young man, at the moment of deciding upon his career, determine as completely and firmly as he can that he will enter upon no course of study or action he has not first decided to be well worth his best effort, and once having reached this decision he should allow nothing to stand in the way of making the strongest effort possible in the particular line of study or action in hand.

The definite knowledge or power gained by conquering as thoroughly as possible each problem attacked constitutes only the smaller part of the benefit derived from pursuing such a course; *the larger benefit comes from the contribution which every such effort makes to the firm establishment of the habit of always being willing to do the best that is in us.* It is impossible to over estimate the importance of such a habit in the development of human power. To send the impulse of strong will along our nerves, setting our muscles in action to perform in the most thorough and efficient manner possible any particular piece of work, not only renders it easier to perform that work a second time, but it actually increases the power to reach a higher standard at every succeeding performance. On the other hand, any falling away from our own highest standard actually weakens our power for any subsequent effort. This is not a statement of fancy, but of fundamental law. These are facts involving the first principles of physiology and psychology, upon the operation of which all evolution depends. It is the ignoring of these principles that leads to that appalling waste of human energy that we may daily witness on every hand, a waste five times as great as the energy required to do the necessary work of the world.

The way, therefore, to conserve our energies to the utmost and to develop our power to the utmost is to undertake no useless or worthless action, and always to do in the best possible manner whatever we undertake. I wish the great importance of these facts could be brought home to every student in our dental schools. Success depends upon these things more than upon all else—not only success in all material ways, but also that higher and more precious kind of success, the success of strong character building.

What the dental student of today most needs is not greater opportunity or greater variety of work, but a nobler ambition and a stronger will to take advantage of the rich opportunities already within his reach; and I think that the teacher places a poor and cheap estimate on his own work and his own duty when he tries to absolve himself in a more or less fictitious rivalry of opportunity for the student. The true teacher, the man who believes in himself, in the real dignity and significance of life, and in the responsibility of his calling, can accomplish far greater results than are commonly realized with far less material or opportunity than exists in any respectable dental college of today. The chief conditions or elements of success lie right here—in starting the student right and helping him into that attitude of mind in which he will place a high value upon himself and in which he will clearly see in his profession an opportunity for noble accomplishments. And in this attitude toward himself and his profession the young man entering upon his life-work will also find the basis of his attitude toward the public, which is the second important element in his success. It is simply impossible for any man to maintain the conditions necessary to success, if, in his relations with the public, he finds within himself the smallest tendency to speak or even secretly *think* in terms of apology for his calling. Even that expression is not quite strong enough to convey the force of my conviction.

CONDITIONS FOR THE DENTAL PRACTITIONER'S SUCCESS

The man who in preparing himself for his life-work has been governed by the principles and conditions I have mentioned should be so well fitted for that work as to feel that he is complete master of the situation in his own domain. His belief in himself and in the value and beneficence of his work should be so strong that he will naturally and spontaneously maintain toward his patients an attitude of quiet, genial, but *masterful* control of all conditions of his practice. While showing a willingness to confer with his patients on all points, he should make them feel that the ultimate decision must always rest with him, nor should there ever be the slightest departure on his part from this position. His future success depends more upon this than upon any other thing except efficiency in his work. But in maintaining this position he should never allow himself to be forced into showing the least irritation with his patients. Great strength lies in an earnest but quiet and finely poised nature. To be masterful does not mean to be overbearing, dictatorial, or over-emphatic. Masterfulness lies in attitude and poise of mind rather than in speech. It is born of character, rather than the accident of position. Probably the silent, secret interplay of psychic forces always really counts for more in human relations than our coarser, more obvious expressions as displayed in speech and action; and these finer forces can be developed only by the practice of the principles already indicated. Next to this more general relation of the dentist to his patient I should mention as important to success the cultivation of methods of operating in which there should be the fewest possible false movements. If almost any man will watch himself closely through one day, I think he will be astonished to see how many movements he makes which count for nothing, which result in no advance in his work. To cultivate to the utmost the avoidance of false movements is not only

to secure great economy of time and energy for the dentist, but it is the most humane method for the patient. It is a curious but easily understood fact that in the work of excavating cavities the more or less false movements of timidity growing out of a desire not to hurt our patients really cause more pain than the work of the firm, sure, bold hand. Most patients are quick to see and appreciate this.

But it is not my purpose in this paper to enter much into the detail of the elements of success. Our society papers and publications in our journals are filled with these details. It is rather my object to call attention to the great foundation principles out of which successful detail is developed. We but confuse our minds when we try to study the meaning of details apart from the great principles which govern their significance.

THE SOURCES OF REAL SUCCESS THE SAME IN ALL CALLINGS

The world's greatest artist, Michelangelo, writing to an acquaintance after the death of his friend, Cardinal Ippolita, said: "I see that I cannot depend upon the promises or assistance of others, but must rely upon myself and try to do something of worth." To rely upon himself, to listen to that inner voice which every man has, and which it always pleased Socrates to call his good *daemon*—that has been the secret of the success of every great man. The elements of success in dentistry are precisely the same as they are in any other occupation that men engage in. Success is not due to any particular method of bookkeeping or any particular way of using particular materials, for that would mean that we are the slaves of our methods, tools, and materials—and that condition is often true, and is why so many only half succeed, or fail altogether. Success is won by our becoming masters of ourselves, our tools, and materials. Real success is won by the constant cultivation of will power, energy, courage, and sincerity, and there is no other secret in success than that. The one great problem of teaching, the all-important condition on which a successful professional man is to be made of a student is how to arouse the latent, dormant will power, energy, and courage of the student; how to make him see and fully realize that success is surely within his reach, that he is the sole arbiter of his own fortunes; that even in such rare instances as when it is one man against the world, the one man may be, if he will, stronger than the world. And the joy of that! The joy of the master, the joy of conquering on your own terms, which you may always do if you are willing to pay the price—the joy of that is beyond anything that life has to offer. There is no more subtly false teaching than that man is the plaything or slave of predetermination, or fate, or destiny. Man is the slave of fate or the universe only to the extent that he is ignorant of or defies the laws of his own being, which are one with the laws of the universe. If there be any legitimate use for the word destiny in connection with man's career, then we may say that man is destined to become the ruler, not the slave of the universe.

To act always with will, courage, and sincerity, and to believe that in so acting all the great powers of the universe are with us, is to insure the best and truest success here; and when we have finished here, along those lines, we shall probably, in the language of Sir Oliver Lodge, "Go upstairs and rule a planet!"

THE SIGNIFICANCE OF SOME NATURAL LAWS IN THE PRACTICE OF PREVENTIVE AND RESTORATIVE DENTISTRY

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THE prosthodontist, the periodontist, the dentist who accomplishes oral rehabilitation by means of occlusal reconstruction, as well as the general practitioner making artificial appliances and fillings, must concern himself with the factors which cause the periodontal tissues to break down. He must also learn the most favorable mechanisms which nature has selected to encourage a healthy periodontium. In this paper, we shall discuss some of the factors which are injurious as well as those which are beneficial to the periodontium, that is, the bone, periodontal membrane and gingival tissue.

It is suggested as a basis for the discussion that we review Box's etiologic chart on periodontal disease.[1]

"1. *Direct factors:* Microorganisms plus their products (and the by-products of injured tissue) i.e., toxins, enzymes, etc.

"2. *Predisposing factors:*

(a) Local: e.g., traumatogenic occlusion, incubation zones, etc.

(b) Systemic: (1) presence of assisting causes, e.g., nutritional deficiencies, hormonal disturbances, etc., (2) absence of preventing properties, e.g., lack of anti-enzymes."

Box further states, "The local basic state of the periodontal tissues is brought about by adaptation to its multiple environment which is the aggregate of all local and general factors. Any disturbing factor, local or general, which tends to deplete the reserve of the local basic state, acts to upset the balance that has been struck between the tissue and its environment and to favor infection."

Thus we see that traumatogenic occlusion is a very important local predisposing factor which may be altered by any of the systemic factors. The local basic state is therefore upset rendering the tissues favorable to attack by organisms. If we analyze the component elements concerned with traumatogenic occlusion more minutely, it will become evident that there are forces which are destructive to tissues not necessarily because these forces are heavy, but because their direction is unfavorable. These factors must be considered in the construction of inlays, clasps, and rests, as well as in the setting of artificial teeth. We may also learn that force may be applied heavily and beneficially if the direction is correct.

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Hay[2] showed that when the direction of a force upon a tooth is in line with its long axis, the bone surrounding the root absorbs the load equally over its entire surface, the relatively small apical area receives pressure within the limits of tissue tolerance. He also showed that by introducing a horizontal component and changing the angle of the direction of force, two pressure areas appear, one at the

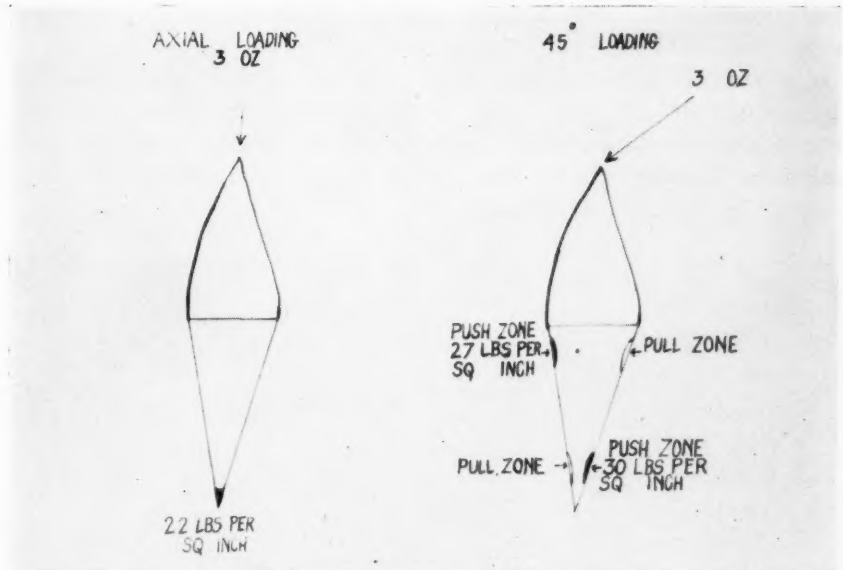

Fig. 1.

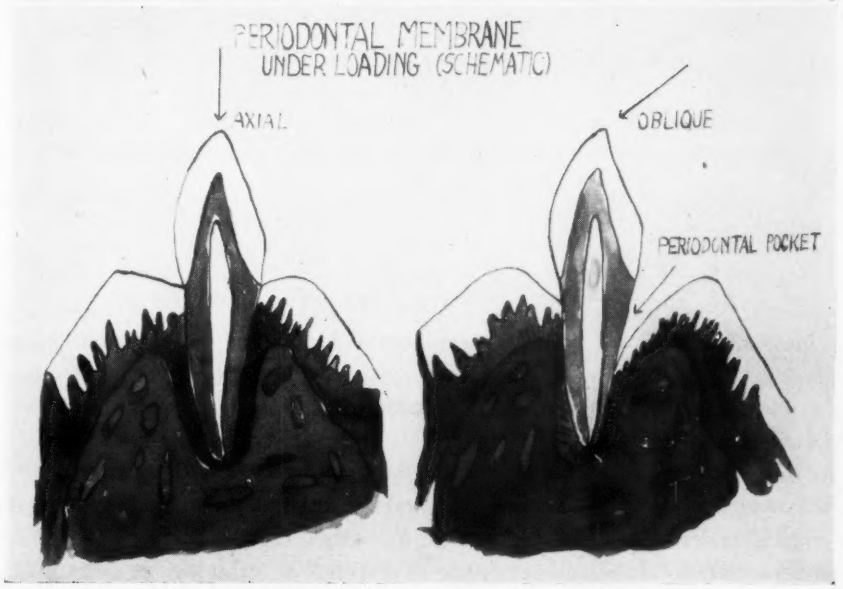

Fig. 2.

Fig. 1.—Simplified interpretation of Hay's formulas.

Fig. 2.—Periodontal membrane under loading (schematic). Under axial loading all the fibers except those at the apex are subject to forces of traction. When an oblique force is applied, relatively few fibers are utilized.

gingival fulcrum and the other at the apex on the same side on which pressure is applied. Translating his formulas into simpler language it may be said that if three ounces of pressure were applied vertically upon a conical tooth, the tissues at the apex would receive twenty-two pounds per square inch pressure, but if the angle were changed to 45 degrees, the pressure at the gingival fulcrum would be twenty-seven pounds per square inch and thirty at the apical region (Fig. 1). The latter pressures could be in excess of tissue tolerance which may vary in accordance with systemic or metabolic factors.

At this juncture it should be pointed out that periodontal pockets generally form at the gingival crevice in the pull zone areas. While it is true that heavy pressure may cause resorption of bone, particularly if it is sustained and in excess of tissue tolerance, actual pocket formation occurs chiefly in areas where excessive traction is placed upon the bone and cementum.

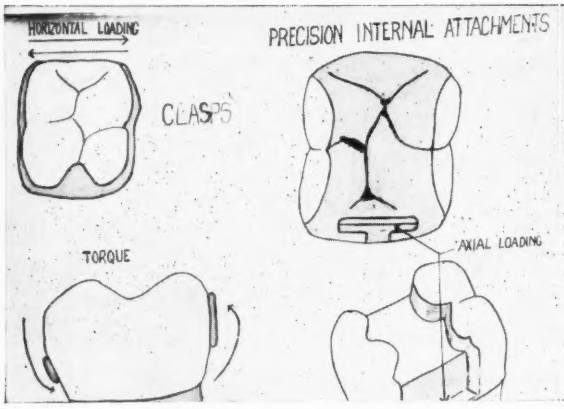

Fig. 3.

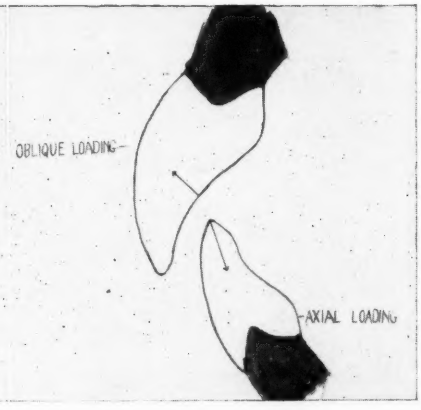

Fig. 4.

Fig. 3.—Clasps produce horizontal loading; internal precision attachments tend to translate forces axially.

Fig. 4.—The direction of force on the upper anterior teeth is generally oblique, while that on the lower anterior teeth is axial.

PERIODONTAL FIBERS

It is important that we discuss periodontal fibers fully. Gottlieb[3] stated "Wherever possible pressure is translated into traction. This is answered by bone deposition. This is not only the case with muscle insertions but also in the suspension of our teeth."

It may be said that a tooth under function is suspended by the periodontal fibers which surround it. When the force is axial, nearly all the fibers around the tooth are engaged, dividing their load. There is, therefore, heavier bone deposition, as Gottlieb stated. When the pressure is directed at an angle we have a new situation. Relatively few fibers are engaged in meeting the forces of traction and they may be inadequate to withstand the strain. On the other hand they may be strong enough but the force is sufficient to break off pieces of cementum from the root surface thereby unfavorably affecting the local basic state.

It may be stated, then, that (1) excessive direct pressures may cause resorption of bone, this being applicable to regional pressure areas on the bone surrounding a tooth as well as on the bone underneath the saddle area of a denture; and (2) excessive traction may also bring about periodontal lesions, a feature of which is the pocket (Fig. 2).

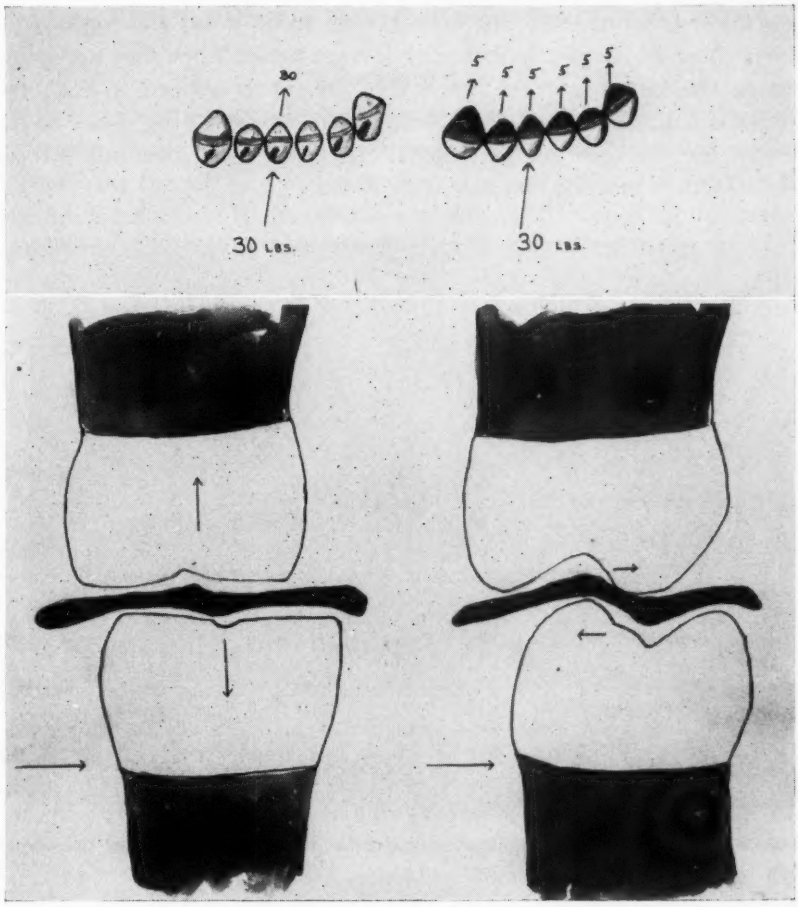

Fig. 5.

Fig. 6.

Fig. 5.—The load on splinted teeth is divided among several teeth where it was received on one or two teeth previously. Looking down incisally on lower anterior teeth.

Fig. 6.—Cusps tend to introduce a horizontal component while the absence of cusps tends to translate the direction of force axially.

These traumatogenic forces are caused not only by maloccluding teeth, but also by horizontal pressures of appliances such as clasps, indirect retainers and rests upon teeth (Fig. 3). Instances are numerous where clasped teeth, receiving horizontal pressure too severe for the patient's tissue tolerance, become loose. On the other hand, relatively mobile teeth have become firmer when internal precision attachments are so constructed that the direction of force on the abutment teeth is axial.

There is no better example that axial loading is the most favorable pressure on the teeth than that demonstrated by the lower anterior teeth as a group. They are generally the very last teeth to be lost, even when tooth loss is due to periodontal disease. When the lower anterior teeth make angular occlusion with the upper teeth, the direction of force is oblique on the upper anterior teeth, but generally axial on the lower ones (Fig. 4). In patients where wear is evident upon the remaining lower anterior teeth, the bone is seen to be broad and high.

It has been observed frequently that teeth become firmer when they are splinted together because the load is so distributed that the forces applied to each tooth become compatible with the tissue tolerance of its environment (Fig. 5). In these cases, as we shall see, the bone and periodontal membrane reorganize into favorable patterns and the teeth in function continue to be useful.

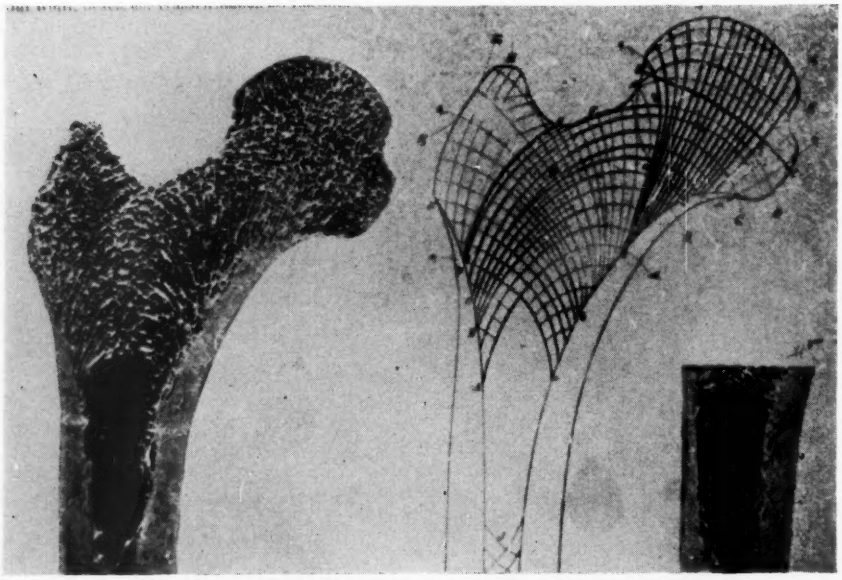

Fig. 7.—Wolff's Law of the arrangement of the trabeculae of bone to meet the direction and intensity of a force.

HEAVY FUNCTION VS. TRAUMATOGENIC FUNCTION

Box[4] stated, "The viewpoint that the greater the functional or occlusal force becomes, the stronger will be the supporting bone would seem to need some qualification. When the cusps have been worn down enough to produce mostly an axial loading, the bone receives the stress more evenly over the entire alveolus (Fig. 6). In consequence, heavy function tends to be beneficial, and may be increased considerably without the danger of overloading. However, in the writer's opinion, great increase in functional stress that acts on the tooth more or less horizontally and is sustained by the periodontal membrane and bone regionally instead of generally is frequently outside the limits of the tissues and is not beneficial."

Heavier pressures are beneficial if they are applied so that the load is distributed on more bone surface and nearly all the fibers are engaged in carrying the burden. Frequently a relatively light horizontal pressure may be too great for either the few fibers receiving it or the cementum to which the fibers are attached, causing it to break away. Apart from the artificial appliances and angular occlusion of anterior teeth, the greatest factor in the overloading of teeth is the improperly worn cusp. This introduces a horizontal component.

THE ORGANIZATION OF TISSUE

It has been a well-established fact that tissues have the ability to organize to meet function. The trabeculae of the bone will rearrange themselves in patterns to meet both the intensiy and direction of a load (Fig. 7). Heavy function that is within the limits of tissue tolerance will not only induce the formation of decided patterns of the trabeculae and results in an increased mineral content, but will also produce a condition of hypertrophy resulting in a greater deposition of bone.

Fig. 8.—Gingival tissues of a Yugoslavian man aged 72 years exhibiting wear. The tissues were of excellent color and tone, and the bone is high. (Courtesy of Dr. C. H. M. Williams.)

The periodontal membrane also possesses the property of organization. The fibers of a tooth will organize, like bone, into a favorable pattern to meet function. A tooth which is out of function is held by fibers which appear to be less organized, containing an abundance of loose tissue between the fibers. It is sometimes advisable to place teeth which have been functionless into an intermediate stage of light function before they are used as abutments. Sometimes breakdown occurs because the quality and organization of the fibers and bone are inadequate to meet the heavy load. Teeth out of function for long periods of time are often poor risks as abutments, both for clasps on partial dentures and inlays of bridges.

After the natural teeth have been ground, and after occlusal reconstruction has been performed in some mouths, subsequent alterations in articulation are sometimes noted. It has been our experience that the alterations in the direction or intensity of forces after equilibration, either by grinding or restoration, not too infrequently cause such a reorganization of the bone and periodontal membrane that subsequent corrections in the occlusion are necessary. These may have to be repeated several times.

DENTISTRY AT THE CROSSROADS

The author is of the opinion that not only is the presence of improperly worn cusps frequently the chief factor in traumatogenic occlusion, but the presence of unworn deciduous teeth probably prohibits the establishment of a favorable anterior end-to-end occlusion on the permanent teeth. This is a serious statement and the time has arrived when dentistry must make its decision whether cusped teeth without wear are normal or abnormal, beneficial or detrimental.

Dentistry is at a crossroad on this subject. Our entire practice is almost completely affected, whether it be the construction of inlays, bridges, or partial dentures and the study of periodontics, orthodontics, or preventive dentistry. Shall we follow the McCollum doctrine, that wear on teeth is pathogenic and that the occlusal surfaces must be restored to their unworn pattern, or the Box concept that wear is beneficial? Studies of nature's mechanisms would appear to favor the latter opinion, and, if this be true, a revision of our concepts of tooth form and prosthetic appliances is in order.

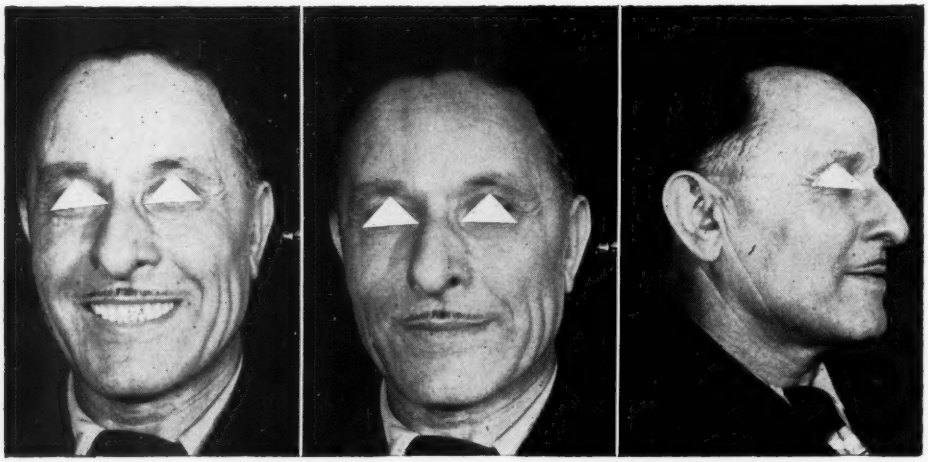

Fig. 9. Fig. 10. Fig. 11.

Fig. 9—Man 64 years of age exhibiting wear on teeth. (Courtesy Dr. C. H. M. Williams.)

Fig. 10—The distance between the nose and chin remains high despite wear. (Courtesy Dr. C. H. M. Williams.)

Fig. 11.—Profile view of the same man. (Courtesy Dr. C. H. M. Williams.)

WEAR

The subject of wear and its benefits has been fully discussed by Box[5]. It has also been discussed in articles by the author[6,7].

The evidence is accumulating that wear is beneficial to the periodontium. Wherever the wear of teeth is observed, even in excessive amounts due to pathogenic conditions, like wasting disease or hypoplastic enamel, the three elements of the periodontium seem to benefit. Tobacco chewers who have excessive wear due to the fine particles of sand present in the tobacco, generally have heavy bone, well-organized membranes, and healthy gingival tissues.

In some sections of the world where the diet contains roughage and requires heavy function, the cusps wear early. These people generally exhibit an end-to-end occlusion of the anterior teeth with its favorable axial loading. Williams[8] is of the firm opinion that wear is beneficial. He was kind enough to permit the use of some of his illustrations. The first one is of a seventy-two-year-old man who was born in Yugoslavia, and who manifests wear (Fig. 8). The color of the gingival tissues is excellent, and the bony structures supporting the teeth are high.

Fig. 12.

Fig. 13.

Fig. 12.—Gingival tissues of Dr. Williams' patient.

Fig. 13.—Wear on deciduous teeth is quite evident in the dentition of this Greek child. Lower permanent anterior teeth have already appeared. (This and the next three pictures were taken by Dr. R. E. Moyers, Professor of Orthodontics at the University of Toronto, in a remote section of Greece.)

The group of pictures on page 310 is of a man sixty-four years of age (Figs. 9, 10, and 11). The distance between the nose and chin remains high (Figs. 10 and 11). In all cases of wear of the teeth, the alveolar bone is high upon the supporting bone, resulting in prominent ridges (Fig. 12). It is only the well-worn teeth that remain in the mouths of old people. Teeth without wear have long since been lost.

All this evidence seems to indicate that wear is a normal process designed to promote a healthy periodontium.

The author has taken the liberty to quote from one of Pleasure's personal communications which express perfectly our attitude on the wear of the human dentition: "Your field, as I see it, is bio-engineering, the study and control of the forces generated (and imposed on the periodontium) by the juvenile occlusal pattern seen upon eruption, as compared to the mature occlusal pattern created by functional contact with the environment. Most of our patients may be said to

be suffering from occlusal infantilism . . . . Occlusal maturity, like emotional maturity, can only be achieved by frequent, unflinching and active contact with the surrounding medium, nutritional or social . . . Our grit-free, soft and civilized diet deprives our teeth of maturation, and allows us to retain the cusps which should recede like the thymus; their persistence tears down our periodontal structures."

Fig. 14.

Fig. 14.—Side view of same child as in Fig. 13. Note wear on posterior teeth. (Courtesy Dr. R. E. Moyers.)

Fig. 15.

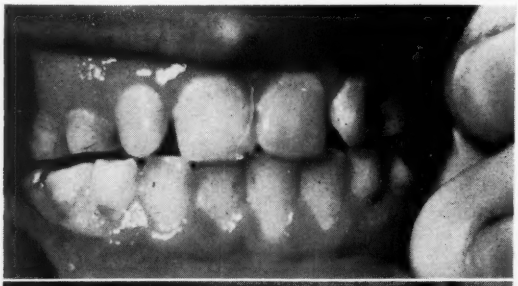

Fig. 16.

Fig. 15.—Another child about 8 years of age with wear on deciduous teeth. (Courtesy Dr. R. E. Moyers.)

Fig. 16.—Side view of worn posterior deciduous teeth of patient in Fig. 13. (Courtesy Dr. R. E. Moyers.)

WEAR ON DECIDUOUS TEETH

The author is of the opinion that the cusps of deciduous teeth should be reduced early, preferably by the proper type of food. This always occurs in the aborigines which we have studied, as well as in others where wear is still present

on teeth. It is our considered opinion that wherever wear is exhibited on deciduous teeth, there is a greater likelihood that the permanent anterior teeth will have a favorable end-to-end occlusion. The enamel of deciduous teeth is much softer than that of permanent teeth, permitting more wear.

At the suggestion of the author, Dr. R. E. Moyers, professor of Orthodontics at the University of Toronto, included a study on the wear of teeth along with other studies on nutrition and caries, in a remote section of Greece, during the summer of 1951. In a statement to the author he emphatically confirmed the relationship between wear of the deciduous teeth and an end-to-end occlusion of the anterior permanent teeth. A statistical report on this study will be published. He was kind enough to permit the use of four of his illustrations (Figs. 13, 14, 15, and 16).

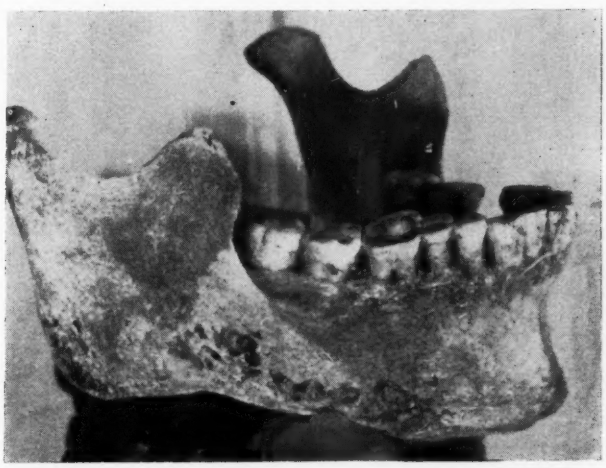

Fig. 17.—The worn dentition on the mandible of an Eskimo found in the Aleutian Islands. (Courtesy of the American Museum of Natural History.)

It would appear to be advisable to reduce the cusps of deciduous teeth by grinding if the abrasive elements in the diet do not do so. The interlocking, unworn cusps of deciduous teeth could be an inhibiting factor of growth in the mandible or maxilla. It does not require much pressure to inhibit growth.

Perhaps the cusps of adolescent permanent teeth should also be slightly, but periodically, ground to effect an occlusal equilibration as well as to encourage this end-to-end occlusion of the anterior teeth, with its healthy periodontium.

GRINDING OCCLUSION

It is advisable to point out here that there is no unanimity of opinion upon the practice of grinding the occlusion of the natural dentitions. Some dentists grind with the aim of maintaining sharp cusps. Others grind the buccal cusps of the upper teeth and lingual cusps of the lowers. Neither of these are following the pattern of nature.

The cusps are flattened in nature, and not maintained (Figs. 17 and 18). Efficiency is not lost in flattened cusps because (1) the greater glide permits more shredding, and (2) the softer dentine cups out leaving hard rims of enamel. The uneven rate of wear produces cutting edges of enamel and food escapes in the dentine. The pattern becomes, in effect, one of inverted cusps like Hall's teeth. This is duplicated in many animals as well as in cusp-wearing humans. Some dentists grind upper buccal and lower lingual cusps for the principal reason that the vertical dimension will not be lost, these cusps being outside the commonly occluding areas. They lose sight of the fact, however, that teeth are nearly always in a continuous state of eruption, and if grinding is slightly overdone, the line of occlusion will, with very few exceptions, be maintained by the eruptive mechanism.

Fig. 18.—Mandible of South Australian Aborigine exhibiting wear of cusp. (Courtesy American Museum of Natural History.)

It is one of nature's evolutionary mechanisms which compensate for the wear to which the teeth of man have been subjected for countless years. Other mechanisms are the recession of the pulp with deposition of calcific material, and the proliferation of bone at the alveolar crest so that the tooth does not leave its socket. These mechanisms are frequently observed when an upper third molar with its entire periodontium moves down after the extraction of the opposing lower teeth (Fig. 19). Only in recent centuries, and then in only a relatively few localities, has the wear of teeth diminished.

Clinical observation appears to support the view that the teeth should be ground chiefly at the expense of the lingual cusps of the uppers and the buccal cusps of the lowers. This pattern has prevailed for perhaps millions of years, and the beneficial results are in evidence in all so-called primitive peoples, as well as in those who live in environments where abrasive elements are still retained in the food (Fig. 20).

COMBINED GRINDING AND ARTIFICIAL RESTORATION OF OCCLUSAL SURFACES

In some mouths occlusal grinding alone may not be sufficient. Areas may have to be built up to obtain a better distribution of force. Care is taken not to use the term balance. With natural teeth, mastication being a unilateral function, there is nothing to balance. With some of the herbivorous animals the upper jaw is wider than the lower so that when one side is in contact the teeth on the other side do not touch at all (Fig. 21). The natural teeth on the nonworking

Fig. 19.—From a cast at the University of Toronto. (Courtesy Dr. R. J. Godfrey.)

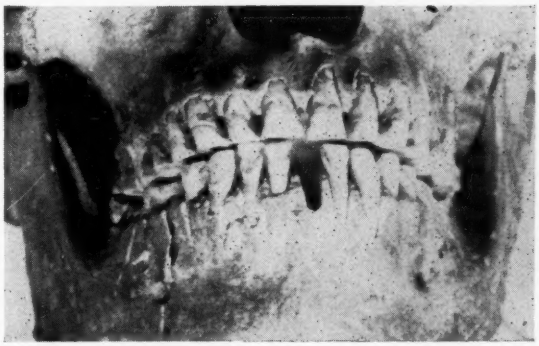

Fig. 20.—Frontal view of same maxilla and mandible of same Australian Aborigine as in Fig. 18. Note high bone on mandible despite wear. (Courtesy American Museum of Natural History.)

side of humans will not tip, nor will they even meet when a bolus of food is introduced on the working side. It is necessary that the direction of force be applied axially even with a bolus of food between the teeth, and that the load on the working side be distributed equally without the presence of food. This can only be achieved by flat-cusped occluding surfaces, brought about either by artificial construction or by grinding.

We therefore fail to see justification for the beautifully organized, meticulously carved cusps engineered by the small group who are able and willing to carry out the technique advocated by McCollum.

IMPROPERLY WORN CUSPS TEND TO BE PATHOGENIC

We have gone to some length in this paper to point out that when a horizontal component is applied to occluding teeth, forces are received regionally rather than generally. Improperly worn cusps tend to introduce this horizontal component. The best that can be said for proponents of well-articulated complete cusps is that the load is distributed on many teeth in all directions. This occurs, however, only when there is the absence of a bolus of food between the teeth. Certainly the direction of force is not purely axial. With a bolus of food, the direction of force must tend to become horizontal with its accompanying hazards.

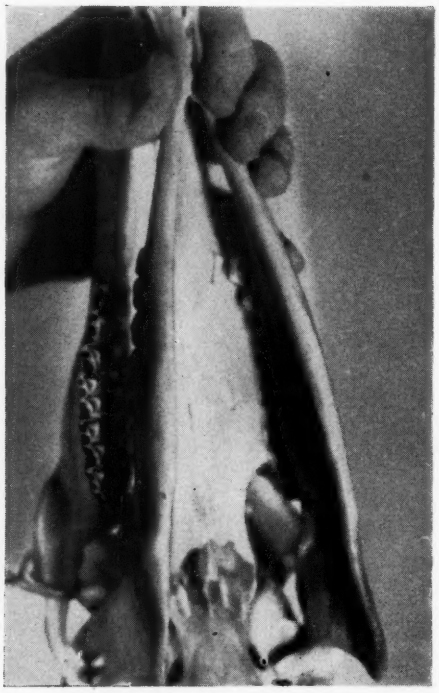

Fig. 21.—Mastication is a unilateral achievement. The mandible in this herbivorous animal is so much narrower than that of the maxilla that when the teeth of one side are occluded, the teeth on the other side cannot even meet.

The great effort and time as well as the money required to master the method and produce good results are not proportionate to the benefits which may be obtained by introducing flattened cusps on the natural teeth either by grinding or with new artificially created occlusal surfaces. The author has seen wonderful and lasting results achieved by grinding alone. It is within the scope of the average practitioner, and many people may be treated. If this practice is instituted early and properly, a great preventive service will result.

Should attempts be made to retain cusp form by means of grinding or by occlusal restorations with inlays and crowns, and should these attempts be poorly executed by dentists taking less care than do these relatively few McCollum

disciples, great injury could result. Injury, of course, could also result by improperly carrying out the principles involving flattened cusps, but the opportunities for error are not as great.

Schweitzer[9] states, "My observations have been that clinically simple theories and simple machines have proved equally efficient and have produced equally good results."

Schweitzer has employed the McCollum instruments, but the author is not certain whether he has carried out the McCollum method of carving cusps. Although the author once owned the instruments, he has not completed a case with the gnathoscope and gnathograph. It did not take too much convincing that the

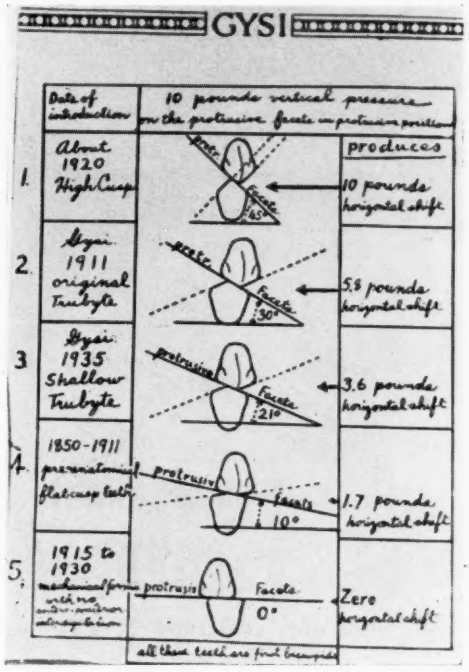

Fig. 22.—Gysi's chart showing that the steeper the cusp, the greater is the force in a horizontal direction. (Courtesy Dentists' Supply Company.)

instruments were among the best ever devised, even though the techniques of registration and mounting were laborious and required meticulous accuracy. Even this is worth while if the greatest beneficial results are achieved and a large number of patients could be treated.

After more than a year's practice of carving cusps for exercise, evening after evening, upon an ordinary anatomic articulator, the method was abandoned. It was fascinating to observe how cusps may be formed in wax and built to integrate in perfect coordination, presenting paraboloid cutting surfaces to the opposing cusps in all positions of articulation. The exercise is recommended to everyone who believes in orthodox dental anatomy and in the articulation of well-formed

cusps. Dentistry owes a debt to McCollum for this, and for his apparent demonstration that the hinge axis exists at a fixed point in the condyle, and that this point may be marked on the face accurately, at least at the time when registrations are made, even if not for life, as he claims.

During these carving exercises it became evident that loading could be directed axially only with flattened cusps. A decision had to be made whether the McCollum concept that well-articulated cusps tend to promote healthy tissues, or whether Box's observations that the well-worn dentitions with their consequent axial loading were more conducive to a healthy periodontium is correct. The latter was our choice. The evidence in its favor is overwhelming. Many patients may be treated and many dentists can be trained to carry out the procedure.

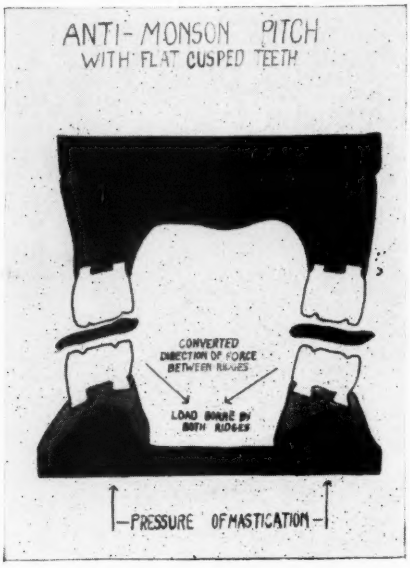

Fig. 23.—The anti-Monson pitch tends to stabilize the lower denture during mastication.

ANGLE OF STRESS IN ARTIFICIAL DENTURES

In the construction of complete artificial dentures, the principles previously expressed hold just as true, with the exception that the overloading is manifested on pressure areas rather than on traction areas. Assuming that the impression technique is an acceptable one, the articulation must be such that, in most positions of the jaw, the direction of force will permit the pressure to be divided over the greatest possible denture-bearing area. Cusps on dentures tend to cause the denture bases to glide when a bolus of food is interposed between the teeth. Gysi[10] once demonstrated how pressure is translated into a horizontal force when cusps are introduced. He worked out a chart indicating that the steeper the inclination of the cusps, the greater will be the conversion of a vertical into a horizontal force (Fig. 22). With flat occlusal surfaces, the horizontal

component is eliminated. If the horizontal force is such that the oblique pressure is borne by a relatively small fulcrum-like area, the load may be too great for tissue tolerance, causing resorption of bone. Vertical pressure will permit more area to be contacted.

Flat cusped teeth tend to translate the load vertically even when the direction of the mandibular movement is horizontal.

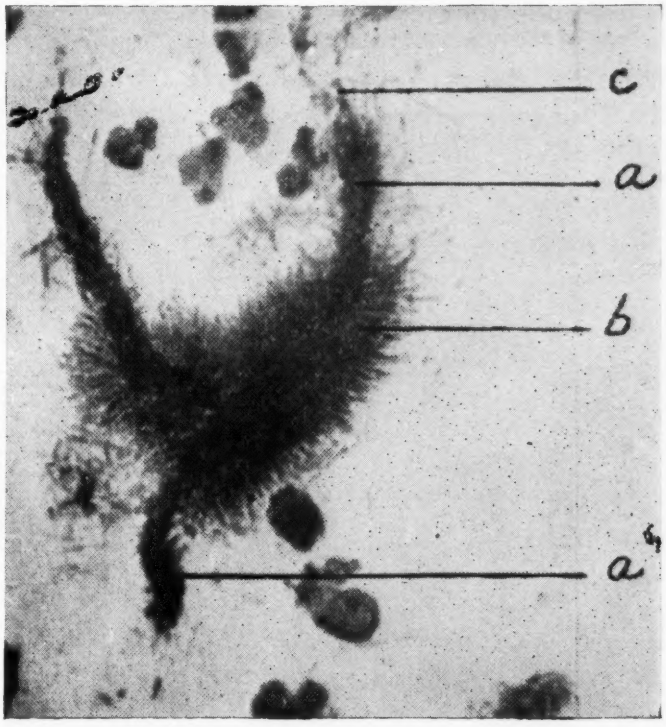

Fig. 24.—One of organisms associated with periodontal disease. This one is a large branching organism. There are other forms found deep in the tissues which may be other organisms or plemorphic phases of the same organism. (Courtesy of Dr. H. K. Box.)

Even if perfectly articulated cusped teeth were to be used in the construction of artificial dentures, it must be remembered that tissues change under the denture base. The bone reorganizes because the direction and intensity of forces have been altered. The softer tissues probably alter, also. Since tissue composed of stratified squamous epithelium upon which the denture rests is not of a static type, cellular alterations probably take place because of the stimuli to which it is subjected.

With even slight alteration of the tissues under a denture base a malarticulation of the cusps occurs, resulting in a shift of the base and probable new pressure points with its subsequent resorption of bone. This sequence of events is less marked with flat-cusped teeth, there being little horizontal shifting of the base.

ANTI-MONSON PITCH

The author[7] has demonstrated how the anti-Monson type of inclination of the occlusal surfaces of teeth tends to stabilize artificial lower dentures during mastication. The lower occlusal surfaces inclining buccally direct the force of occlusion towards a central point between the ridges. Pleasure[11], who coined the term "anti-Monson" as opposed to the present concept of buccolingual inclination of the posterior teeth, has also advocated such a method of setting up teeth, using an adjustable articulator and achieving balance with the second molar teeth. Each of us was unaware of the other's conclusions, although Pleasure probably preceded the author by about two years.

Fig. 25.—Pathway of destruction which destroys the tissues towards which it veers. There are necrotizing processes which destroy bone, periodontal fibers, cementoblasts, vessel walls and nerve tissue. (Courtesy of Dr. H. K. Box.)

It would appear that since the direction of force is inward, somewhere between the ridges, the load is distributed over both right and left ridges, there being no fulcrum of tipping such as generally occurs when the direction of force is to the buccal, or outward. Thus we have the advantage, not only of stability, but of the distribution of force over a greater area (Fig. 23). The pitch should not be steep, however, or the load might be horizontal in effect, like with steep cusps.

PARTIAL DENTURES

With partial dentures, steep cusps tend to produce lateral loading on the abutment teeth. It is probably more important that the load is vertical with partial dentures than with complete dentures. The abutment teeth receive pressures from the appliance as well as from their own individual function.

ORGANISMS

We can not do justice to any paper which deals with tissue destruction unless we devote attention to the direct factor outlined in Box's etiologic chart, namely, microorganisms. Box has hypothesized that there are fungus-like organisms (Fig. 24) associated with periodontal disease.[12] They are found whenever a state of disease is present in the periodontal tissues. They may also be present in edentulous areas.

These organisms liberate enzymes which filter through the tissues, sometimes, cutting a swath like a hurricane (Fig. 25). If the path is in the periodontal membrane, the fibers are destroyed; if it veers towards the cementum, the cementoblasts are killed; if it touches bone, bone is destroyed. This is very clearly seen in microscopic sections. We have missed it before because we have not carefully followed through our microscopic sections serially. Very recently, enzymes have been observed to filter through the fine intercellular substance of epithelial cells.

When specific organisms are present in disease, it is because this environment is favorable to them. Every living organism has its own specific environment in which it thrives best. A lion is not found in the arctic; neither does a polar bear live in the tropics. A cactus plant does not thrive in frigid zones nor does a Northern pine tree survive tropical heat.

Therefore, in order that the specific microorganisms described by Box in this field should prosper, it follows that their environment must be favorable. There may be both systemic and local factors which create this environment, as has already been mentioned. Traumatogenic occlusion is a most important local factor. Perhaps the anti-enzymes are removed, permitting the pathway of destruction to continue. (*Note.* "The absence of preventing factors" in Box's etiologic chart).

Of great significance to the dentist is the fact that there seems to be no limit to the distances which enzymes and the invading organisms may travel. We have seen them deep in the bone, and they may well be the cause of some of the excess resorption of alveolar ridges as well as of diseased and uneven bony ridges which we often see under dentures. These organisms have been found as far distant as the glands of the neck. Who dares to say that they do not travel much farther in the body? There is similarity, for instance, in some vague hemorrhages occurring in other tissues of the body, to hemorrhages caused locally in the periodontal tissues. We have seen the path approach a blood vessel, destroying the coat and causing the blood to spill out. When this pathway of destruction cuts a nerve in the gingival tissues (as has actually been seen), can we say that it would not do so in another part of the body?

The statement that "the mouth is the gateway to disease" is certainly no exaggeration.

The onus on dentistry is great! If these microorganisms are as potent as they seem to be, and if they gain entrance by the gingival tissues, we must so condition these tissues that the environment is uncomfortable for them and so reduce their virulence. Much of this may be achieved by the proper application of common sense, keeping in mind the direction given in Box's etiologic chart.

We have attempted to translate these laws into terms of interest to a society

of prosthodontists. Dentistry should be more concerned with biologic principles than with mere mechanics. Our profession is maturing.

SUMMARY AND CONCLUSIONS

1. The local predisposing factor, traumatogenic occlusion modified by the systemic, or metabolic factors is a potent agent of tissue breakdown.

2. Funguslike organisms appear to be direct factors of destruction when the predisposing factors either prepare the tissues for them or remove the protective barriers against their enzymes and toxins.

3. Direction of force must be axial or vertical rather than oblique or horizontal, both on teeth and edentulous areas.

4. Heavy pressure may be beneficial if it is properly directed.

5. Oblique pressures are most destructive. This applies both to occluding teeth or prosthetic appliances.

6. Prosthetic appliances creating adverse direction of pressure cause the breakdown of tissues.

7. Cusps with steep incline planes create potential factors of tissue breakdown, both with natural and artificial teeth.

8. Wear of cusps is conducive to health in the periodontium, and should be instituted early.

9. Flatter occluding surfaces tend to direct the forces of occlusion into an axial direction.

10. Lack of wear on deciduous teeth may be a cause of the absence of an end-to-end occlusion of the permanent teeth.

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COMBINED VULCANITE AND ACRYLIC DENTURE

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WITH THE almost universal acceptance of the copolymer resins as denture base materials, the esthetic and lifelike qualities of our prosthetic restorations have tremendously improved. Probably no one would want to go back to the days of vulcanite, and yet as a denture material it has a certain redeeming quality which our modern resin materials seem to lack. That is, its seeming ability to be more adhesive than the acrylic resins under less favorable conditions. Whether this is because of the character of the mucous film which forms between the tissue and the vulcanite, or whether the difference of texture of the two materials makes the vulcanite more retentive we do not know, but clinically we believe it has shown itself superior in this respect.

It is interesting to note that we have stepped from the "frying pan" of "rubber sore mouth" into the "fire" of complaints of burning and irritation from patients wearing acrylic dentures. On clinical examination some will show little sign of inflammation. Others show definite inflammation and chronic lower ridge soreness. The first procedure is to determine which of several factors might be the cause. If the dentures are built at too great a vertical dimension, or poorly articulated, or out of centric relation, the patient will show evidence of trauma. Pressure on the palatine foramina or the mental foramina will cause burning or some numbing sensation. Improperly cured bases are irritating and should be re-processed. These are some of the mechanical and chemical considerations.

Systemically, we should check for anemia, diabetes, and dietary information for possible avitaminosis, particularly lack of vitamin C and the B complex. A high blood sugar with no spillover into the urine will still cause the same mouth conditions we see in a true diabetic patient. If an allergy to the material is suspected, it can be checked by placing a small flat piece of the same acrylic under a piece of adhesive tape on the inside of the upper arm.

Having eliminated all of these possibilities, however, we still find the occasional patient who has allergy symptoms but gives a negative patch test. In many of these patients, we have tried lining the dentures on the tissue surface with 0.001 tinfoil and found that the symptoms disappeared. This, then, seems to be a sensitivity to something under the denture but not to surfaces which are exposed to air and saliva. Changing to a metal or vulcanite base with acrylic "topsides" has eliminated the trouble in most of these patients.

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In these cases and in those with very flat, sensitive lower ridges and large inter-ridge spaces, the author has had very gratifying results by using a vulcanite baseplate on which the acrylic resin is processed similar to the old double vulcanization technique. The impression is made in the usual way, being careful to include as much area as possible in the outline form. On the resulting cast is adapted one thickness of baseplate wax to the tissue outline. A thin strip of wax is now

Fig. 1.

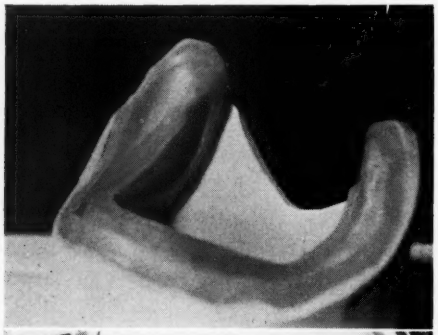

Fig. 2.

Fig. 3.

sealed around the borders of the entire periphery leaving the superior edge spaced from the first layer of wax, and in line with the expected contour of the denture above it (Fig. 1). A thin strip of wax is then sealed around the crest of the ridge extending it distally to the mesial of the molar. The lateral edges of this strip are free (Fig. 2). This base is now packed and vulcanized with a good base rubber. Registering and recording the jaw relations, setting the teeth, etc., are accomplished in the usual manner, and the dentures are waxed and flasked. Either

upon separation of the flasks, or before setting the teeth, a 33½ inverted cone bur can be used to make numerous pits in the surface of the vulcanite to be covered by acrylic. These, along with the peripheral strip and the one on the crest of the ridge, offer adequate mechanical retention for the acrylic. Before packing the acrylic, it is well to thoroughly clean the vulcanite baseplate and then paint its surface with acrylic monomer. When processed and polished, the denture will have the esthetic qualities of acrylic, but will be more retentive and comfortable in the mouths of these problem patients (Fig. 3).

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A PRELIMINARY STUDY OF THE LATERAL DEFORMATION OF METAL BASE DENTURES IN RELATION TO PLASTIC BASE DENTURES

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NUMEROUS investigators have recognized that metal base dentures are more "tissue tolerant" and resistant to deformation than plastic base dentures.[1-5] However, to our knowledge, the amount of deformation that takes place while bases are actually functioning has not been investigated.

PURPOSE

The main objective of this experiment was to determine if (1) a metal base denture was more resistant to deformation while undergoing the forces of mastication than an all-plastic base denture; (2) to determine quantitatively the difference in lateral deformation in the two types of denture bases; and (3) to establish a method by which the foregoing may be determined.

METHOD AND MATERIALS

The method of investigation employed is a modification of the method used by Lissner and Gurdjian.[6] Two electric resistance bonded SR-4 strain gauges are attached to the lingual portion of the lower denture base near the midline (Fig 1). By placing one gauge directly superior to the other, torsional rotation with the denture base may be recorded. However, this is not within the scope of the investigation, and the discussion is restricted to deformation that occurs in the horizontal plane only.

Thin wire leads causing minimum interference with the adjacent tissues extend from the strain gauges to associated electronic equipment and on to a multichannel pen recorder.

When a change occurs in the form of the denture base in the horizontal plane, it is recorded as a wave on a strip of paper moving at a known rate (Fig 2). Each wave in the chart represents deformation of the denture base due to a masticatory stroke or swallowing. The amplitude of the wave indicates the amount of deformation within the base: therefore, we can say that the amplitude of the recorded wave

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and the deformation in the base are in a linear relation. The more closely the ascending portion of each wave approaches a vertical direction, an increasing degree of the rapidity with which deformation takes place is indicated. The descending part of the wave indicates the relative recovery of the base.

The subject was a 35-year-old woman who had previously worn full upper and lower dentures for three months. The dentures were fabricated with a methyl

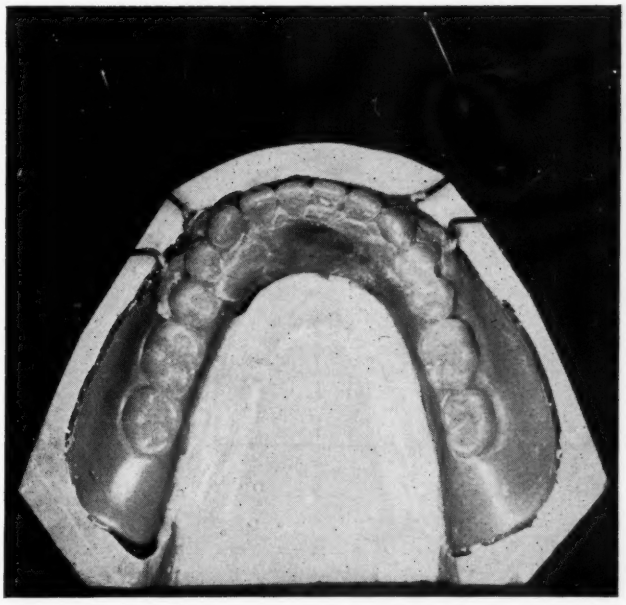

Fig. 1.

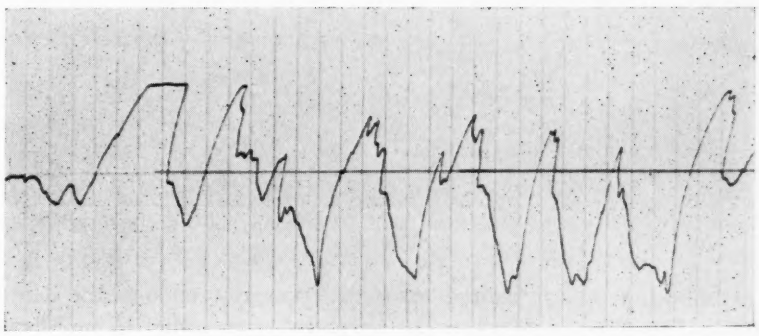

Fig. 2.

methacrylate denture resin, and contained 33 degree porcelain posterior and porcelain anterior teeth. The dentures were set up and milled on a House articulator which was adjusted with plaster checkbites. After the recordings were made, a 28-gauge cast gold base of Ney No. 3 gold (Brinnel hardness No. 225) was inserted in the plastic base by rebasing, and a second recording of the case was made. This

procedure was chosen for the investigation because the position of the strain gauges remains the same.

No instructions were given the subject as to how she should chew. Two foods were used which have a wide range in physical properties for the test. Salted peanuts were selected to represent a brittle type of food, while raw carrots were selected because of their toughness. Both types of food were used because Yurkstas and Manly[7] have shown that denture wearers do not obtain related performances characterizing masticatory function in soft or tough foods.

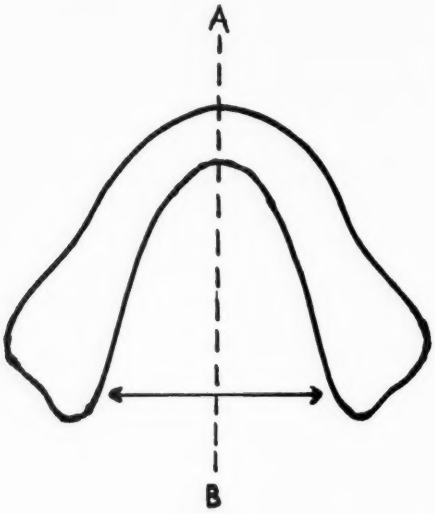

Fig. 3.

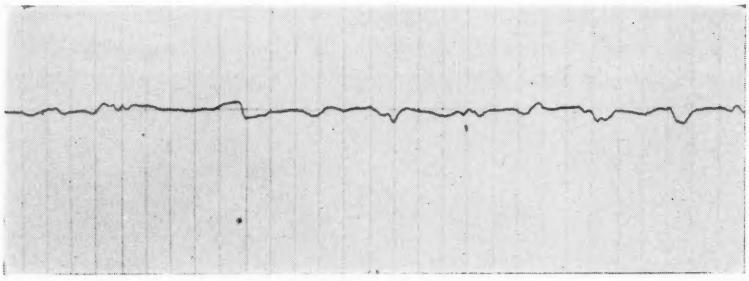

Fig. 4.

The deformation was measured across the posterior ends of the denture from the distal end of one lingual flange to the distal end of the other lingual flange. The deformation is referred to as distortion toward the midline, or away from the midline (Fig. 3).

Results

PLASTIC BASE DENTURE

There was a 3.6 mm. deformation of the denture base toward the midline on the initial biting stroke while chewing carrots. The time required for the denture to reach its maximum deformation was 0.44 second, which was maintained for 0.6 sec-

ond. The recovery period required 0.5 second. One second later there was a 1.5 mm. deformation of the base away from the midline. The average deformation recorded for the plastic base denture is given in Table I.

The amount of lateral deformation diminished as the patient continued to reduce the size of carrot bolus to the point of swallowing. Upon swallowing, there was a very definite deformation of the base away from the midline.

There is speculation on the point that this "swallowing deformation" of bases is caused by the tongue as the bolus of food is carried posteriorly and inferiorly past the soft palate by the tongue.[8]

This is an analysis of the deformation occurring while the patient bit off, masticated, and swallowed a bolus of carrot. The findings here could be taken as a maximum of the performance during the five times the patient was asked to masticate a section of carrot with a plastic base denture.

TABLE I. PLASTIC BASE DENTURE

TYPE OF FOOD	BOLUS NO. CHEWED	AVERAGE DEFORMATION TOWARD MIDLINE (MM.)	AVERAGE DEFORMATION AWAY FROM MIDLINE (MM.)	AVERAGE NO. CHEWING STROKES	AVERAGE TIME REQUIRED BEFORE SWALLOWING (SECONDS)
Carrots	5	1.332	1.8	26.8	26
Peanuts	1	1.32	1.92	31.5	32

In chewing the peanuts, a much smaller initial biting deformation was recorded. The average deformation (Table I) of the thirty-six biting strokes was comparable to that of the carrot average, with one significant difference: the duration of deformation was much shorter. The time elapsed from the base line to maximum deformation and back to the baseline was 0.2 second.

METAL BASE DENTURE

There were five carrot boluses and one peanut bolus chewed with the metal base denture (Table II). When carrots were used, a maximum deformation of 0.36 mm. toward the midline was recorded. The time required for maximum deformation was 0.4 second, with a recovery period following of 0.2 second. The maximum

TABLE II. METAL BASE DENTURE

TYPE OF FOOD	BOLUS NO. CHEWED	AVERAGE DEFORMATION TOWARD MIDLINE (MM.)	AVERAGE DEFORMATION AWAY FROM MIDLINE (MM.)	AVERAGE NO. CHEWING STROKES	AVERAGE TIME REQUIRED BEFORE SWALLOWING (SECONDS)
Carrots	5	.09	.21	26	22
Peanuts	1	.168	.24	30	27

deformation away from the midline was 0.3 mm. and was much more consistent, occurring two to three times in the chewing of every bolus of carrot.

There appeared to be proportionately more deformation away from the midline than toward the midline.

The amount of deformation was much more constant throughout the chewing of the entire bolus with the metal bases than with the plastic bases (Fig. 4). With the metal bases, we still noted a "swallowing deformation away from the midline," as was previously noted with plastic bases.

CONCLUSION

Although this report deals with only one case and would not be statistically valid, it was found that the metal base denture was more resistant to lateral deformation while undergoing the forces of mastication.

Quantatively, we found the metal base denture was 8.5 times more resistant to lateral deformation than the plastic base denture.

It is our belief that the deformation in the plastic base denture for this case may have contributed materially to an atrophy of the alveolar ridge.

Acknowledgments.—Our thanks are extended to Dr. Allan Scher and Dr. Allen Young of the Department of Physiology and Biophysics, University of Washington School of Medicine, for the use of their laboratory and equipment, and their many helpful suggestions, without which we would have been unable to undertake this investigation.

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NONWARPING BASEPLATES

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MANY TIMES the diligence and care given to full denture impressions are completely wrecked by using warped baseplates for jaw relation registrations. A few hours after the baseplates are made, the expansion and contraction of the materials used for their construction renders many of them unfit for use because they do not fit either the cast or the mouth.

A very accurate nonwarping baseplate can be constructed which will eliminate many errors in the registration of the hinge centric and eccentric relations.

TECHNIQUE

Examine the edentulous casts for undercuts, and eliminate them by adding wax. Use one of the cold cure tray materials which are available to make the baseplate. Adapt the material to the cast according to the instructions of the manufacturer. After the material has set and the baseplate is trimmed, you will observe that it is not perfectly adapted to the cast.

In order to perfect the adaptation, reline the baseplate with the same cold cure tray material mixed to a thinner consistency. Allow the reline to set, then trim it. If this is carefully done, the relined baseplate will fit the cast as accurately as the finished denture (with the exception of the undercuts which have been blocked out).

The same procedure can be used for partial denture saddle areas by adapting this tray material to the gold frame work of the partial denture, and relining it after the original shrinkage has occurred.

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SOME COMPARISONS OF SELF-CURING AND HEAT-CURING DENTURE RESINS

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INTRODUCTION

During the past year or more there has been a continued and growing interest in the self-curing resins for denture base applications. The general adoption of the heat-cured methyl methacrylate type of denture base resin by the profession and patient gives a standard by which comparisons in properties of other types of resins can be made. To this time, only limited reports of studies are available for making these comparisons, and further studies should contribute much to the understanding of these cold-cured materials.

The cold-cured or self-cured type of resins lend themselves well to comparison with properties of the heat-cured type by giving consideration to the chemical nature of the two types of materials. It is now common knowledge that chemically the chief difference between the two is the method of initiation or activation of the polymerization process. One is accomplished by the presence of a small amount of an appropriate chemical, while the other is brought about by the application of heat to the plastic mass. Fundamentally the two types are therefore quite similar in basic composition except for minute differences in essential ingredients. It is to be reasoned, therefore, that the self-cured resins for dentures may have physical and mechanical properties as good as, but generally no better than, the heat-cured resins. As is often true, however, with two substances that are very similar in nature, one may lend itself better to certain adaptations or techniques than another. This may be a most favorable feature of the self-curing resins for denture bases.

PHYSICAL PROPERTIES

Since there is an A.D.A. specification designed on certain physical properties with a purpose to indicate the quality of heat-cured acrylic denture resins it is normal to employ the same tests and measurements to indicate the comparative quality of the self-cured materials designed for the same purpose. Such tests

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already have been made by reliable investigators and were reported before the American Dental Association in 1951 and published in the Journal of that Association.[1] In general, it has been determined that the self-curing resins have slightly shorter working time than the heat-cured types; they have less strength and many brands have less favorable color stability, although the water sorption and solubility properties are satisfactory. It seems reasonable to expect that most of the shortcomings can and will be improved to the point where the values approach those for heat-cured products.

WORKING TIME

Results obtained in the Physical Research Laboratory at the University of Michigan, School of Dentistry, have indicated that the average self-curing resin reached a suitable doughlike consistency for packing in about one-third the time that is required for heat-cured products. The average time for seven self-cured resins was 4.5 minutes, while many heat-cured resins require 12 to 15 minutes to reach the same packing consistency. The time for the seven products varied from 1.5 minutes to 7.5 minutes, as is shown in Table I. The amount of powder required for 1 c.c. of liquid varied slightly for different products, but was not significantly different from that of heat-cured resins as has been reported previously.[2, 3] No correlation seems to exist between the powder-liquid ratio of different products and the time required to develop a suitable packing consistency, which is similar to observations made with heat-cured resins.

TABLE I. TIME TO REACH PACKING CONSISTENCY

PRODUCT (SELF-CURED)		GRAMS POWDER FOR 1 C.C. LIQUID	MINUTES TIME BEFORE PACKING
1		1.9	1.5
2		2.3	6.0
3		2.4	7.5
4		2.4	6.5
5		2.5	3.0
6		2.7	5.0
7		2.8	3.0
(HEAT-CURED)	Average	2.4	4.6
8		1.9	15.0

TRANSVERSE STRENGTH AND HARDNESS

The transverse strength of the self-cured resins has been shown to be less than for heat-cured resins,[1,3] unless the resin mass is subjected to a boiling water bath for a brief interval or permitted to stand for two to four weeks before testing. Recent results obtained on six products indicate the same tendency with one exception, as shown in Table II. Individual values vary somewhat from those reported by other investigators which may be the result of experimental differences in testing, but the results are in the same order of magnitude. After boiling for one hour, the transverse strength values at body temperature are comparable to those for heat-cured resins.

TABLE II. TRANSVERSE STRENGTH AND HARDNESS

PRODUCT	MM. DEFLECTION (1,500-3,000 GRAMS)		ROCKWELL SUPERFICIAL HARDNESS	
(SELF-CURED)	AS CURED	BOILED	AS CURED	BOILED
1	2.3	1.9	91.5	93.3
2	1.9	1.5	91.5	93.7
3	2.0	1.5	92.2	92.7
4	2.0	1.5	89.7	90.2
5	2.0	2.3	92.4	93.0
6	2.2	1.9	92.2	94.7
(Heat-cured)				
1	1.6	—	92.7	—
2	1.5	—	92.7	—

It is to be observed also from Table II, that the hardness values at room temperature all increased slightly when the resin was boiled for one hour. The Rockwell Superficial Hardness test was used, with a half inch ball and 30 kg. load, with fifteen second loading and recovery periods. The hardness tests were made on the same samples which were used for transverse tests which were of standard specification dimensions. These results on both deflection and hardness indicate that the polymerization process is not complete and the ultimate properties have not been attained when first processed by the cold cure method. Tests in both the "as cured" and "boiled" conditions were made within twenty-four hours from the time the flask was packed. Similar observations have been reported by McCracken[3] who also observed that comparable increases in strength and hardness occur when the resins are allowed to remain in 37° C. water for a period of two to four weeks. Accordingly, there seems to be little necessity for the boiling operation.

FLASK TEMPERATURE AND SEPARATORS

Some manufacturers have recommended the use of flasks that have been warmed slightly above room temperature for use when processing self-curing products. A few transverse tests on both a self-cured and a heat-cured product in-

TABLE III. EFFECT OF MOLD TEMPERATURE AND FOIL SUBSTITUTE

PRODUCT (SELF-CURED)	CONDITION	MM. DEFLECTION (1,500-3,000 GM.)
No. 4	Tin foil—Room temperature mold	1.9
No. 4	Tin foil—120° F. mold	2.0
No. 4	Substitute—Room temperature mold	1.5
No. 4	Substitute—120° F. mold	1.8
(Heat-cured)		
No. 1	Tin foil—Room temperature mold	1.6
No. 1	Tin foil—120° F. mold	—
No. 1	Substitute—Room temperature mold	1.5
No. 1	Substitute—120° F. mold	1.6

dicate that no increase in strength results from such practice. Although this factor should be investigated further, the results presented in Table III, together with other values not reported from an incomplete series of tests, tend to suggest that the room temperature mold gives more favorable results than the mold warmed to 120° F. before packing the resin mass. The practice of using a preheated mold cannot be recommended, since it does not appear to offer any advantage with self-curing resins; and, because there are several disadvantages related to increased rate of polymerization and lack of adaptation to the mold, the warm flask appears contraindicated.

Some tests on transverse strength have been made to determine if the strength of the resin was modified significantly by the use of tin foil or a substitute in the mold as a separator. The tin-foil substitute Colorgard was used to replace tin foil in a series of samples, some typical values of which are shown in Table III. As can be seen, it is apparent that the self-cured resins are not severely damaged by the presence of a tin-foil substitute in the mold. More studies are indicated to establish with certainty the true value when tin-foil substitues are employed.

COLOR STABILITY

In recent years, the color stability of the heat-cured resins has been developed until now it is a reliable and satisfactory characteristic. While the quality of the color esthetics may be questioned, the permanence of the colors which are available is generally accepted as being good in the heat-cured products.

Several self-cured resin products have been tested according to A.D.A. specification methods of measuring color stability. As has been reported by other investigators,[1] a small number of products appeared satisfactory when examined visually, and the others showed varying degrees of discoloration after being subjected to the radiation test. It has been observed also that some clear, unpigmented, self-curing resins show evidence of discoloration when subjected to this same test. For this reason it is suspected that a better adjustment of the minor chemical ingredients used to control the reaction rate will improve the color stability of the self-curing products.

FLEXURE FATIGUE

Very little has been reported in the literature on the flexure fatigue characteristics of denture resins, although it is recognized that dentures are subjected to repeated cycles of stress during the chewing process. In order to compare the flexure fatigue characteristics of a heat-cured and self-cured type of resin, the machine described previously[4] and used for fatigue testing of gold alloys was employed. Resin samples of the same dimensions as those used for transverse tests were employed in this machine. The sample was supported as a cantilever beam with the free end displaced by measured amounts, which introduced different stresses into the specimen. The machine was originally designed to operate at approximately one million cycles each twenty-four hours, but at lower stresses the speed was increased to about three million cycles each twenty-four hours, with no sig-

nificant change in results. A total of seventeen heat-cured and seventeen self-cured specimens were prepared, using controlled and recommended curing practices for each type of product. When the test specimen would withstand approximately 10 million cycles it was considered that the specimen could be flexed indefinitely without failure from fatigue.

Results of individual tests on one product of each type are shown in Fig. 1, which indicate that the endurance limit of these resins is reached at about 1200 pounds per square inch stress. All samples subjected to more than this stress broke during the test. No significant difference was observed between the heat-cured and self-cured type of resin with respect to fatigue values.

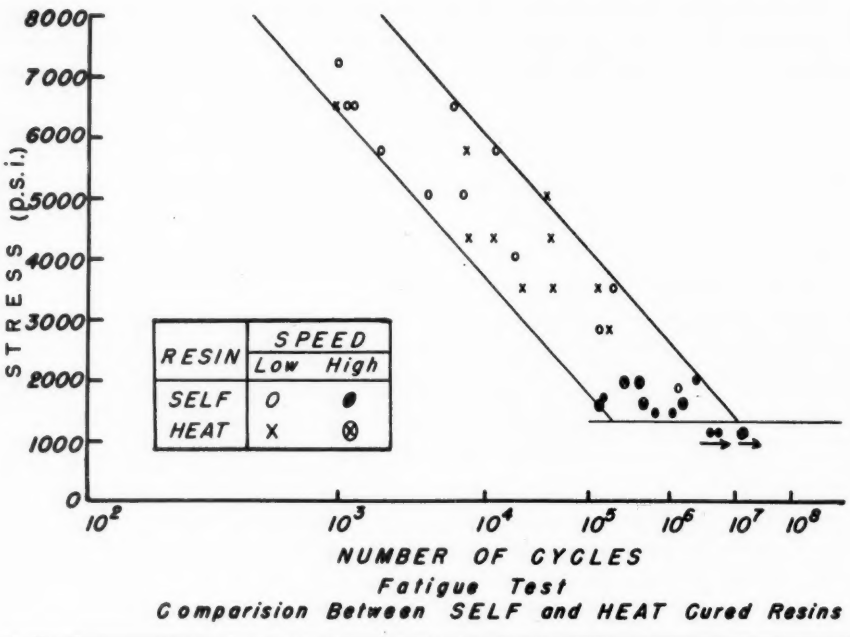

Fig. 1.

BONDING TO ACRYLIC TEETH

The resistance of both heat-cured and self-cured resins to bonding to acrylic teeth continues to be a problem of some seriousness in denture prosthesis.[1, 3] It has been pointed out that the retention of plastic teeth in self-curing resins is accomplished by mechanical means at the present time. Tests also have been described to show how essential it is that the plastic teeth be extremely clean and free from wax, tin-foil substitute, or any other residue if the teeth are to be held securely.

A series of tests have been made which indicate that the attachment of acrylic teeth to self-cured resin may approach the attachment of acrylic teeth to heat-cured resin. Test samples were prepared in which the acrylic tooth was inserted into the center portion of a tensile test bar, with denture base resin serving as the end portions of the bar, similar to the method described by Schoonover and associates.[5]

In a number of cases where wax was allowed to come in contact with the tooth and subsequently removed with insufficient care, the bonding characteristics to self-curing resin were so poor that the sample broke during normal handling. In several instances where extreme care was used to avoid wax or other contamination on the teeth, the attachment of the teeth to the resin was greatly improved, but no results were obtained where the bond area had a strength greater than the resin or the tooth material. More study is being given this problem to determine the degree of bonding that may be developed, and to determine the most successful technique for maximum attachment of teeth to the self-cured resin.

DISCUSSION AND SUMMARY

The results presented in this report are not intended to represent an exhaustive study on the properties of self-cured resins. In summarizing the physical characteristics of the self-curing resins in comparison to the heat-cured resins for dentures, it appears that enough studies have now been reported to establish certain trends in behavior. Even though values are different for the two types of products, the interpretation is not necessarily made that the self-curing products are always inferior to the heat-cured type. Differences in some properties may be considered advantageous.

The working time for self-curing resins is shorter than for heat-cured products. In many instances this is not a disadvantage, and since different products have different working times, it seems probable that this property may be controlled or varied the same as it has been for heat-cured denture resins.

Although the initial transverse strength of the self-cured resins is approximately 15 to 20 per cent less than the heat-cured resins, the strength value varies with different products and the processing procedure, as well as the time of testing after processing. All such variables should be considered in making a comparison on the basis of this property. Since there is practically no evidence to indicate that a slightly lower transverse strength results in failure in service, it may be questioned if the strength of self-cured products is not adequate.

The hardness of the self-cured resins approaches closely to that of heat-cured products at the end of a two-week interval. Since lower hardness and strength values are observed when the resin is initially deflasked, the polymerization process apparently is not complete until some time after deflasking. To date there has been no evidence to indicate that this is a serious disadvantage.

The technique for using the self-curing products most effectively has not been well described, and more studies are needed in this area. Minor variables, such as flask temperature, apparently yield different properties in the finished

structure, for which reason many of the other variables in processing the structure should be investigated.

Results indicate that self-cured resins may be comparable to heat-cured resins in flexure fatigue characteristics. The color stability of some self-cured products approaches that of heat-cured resins. The bonding of acrylic teeth to self-cured resins is a problem which needs further study. If proper precautions are observed in the technique of construction, there are apparently few failures in service that result from failure of bonding of the teeth to self-curing products.

It is seen, therefore, that the self-cured products do not possess characteristic physical properties that are superior to those of heat-cured products. In general, some self-cured products are comparable to the heat-cured type in certain properties, and all self-cured products approach the heat-cured in many of their physical characteristics. In such qualities as ease of processing, adaptability to mold form, and dimensional stability or warpage of the structure the self-cured products are generally recognized as being equal or superior to the heat-cured type.

Thus it becomes evident why the self-cured products have not completely replaced the heat-cured resins for dentures. With the heat-cured products generally giving satisfactory service, the manufacturer or distributor may be reluctant to promote a product that is no better and in competition to present heat-cured products. The profession and laboratory trade may be hesitant to adopt self-cured products because techniques and facilities are available to produce satisfactory heat-cured structures.

It is anticipated that further modifications in properties of the self-cured resins for dentures will occur in the future as a result of improved manufacturing processes. It is expected also that some modifications in processing techniques will lead to improved prosthetic structures. With such improvements, and the presentation of evidence that self-cured resins do not result in inferior structures, there should be a continued increase in the extent to which the self-cured products are used for reliable prosthetic service.

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CHARACTERIZATION OF DENTURES

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RECENTLY a special issue of a leading national magazine[1] was devoted to "The American and His Economy." The statistics are staggering, but the prosperity of today is providing Americans with business undreamed of three decades ago.

This substantial increase in income is reflected in the individual pay envelope, and with the majority of our population engaged in public business, esthetic dental restorations have become an economic necessity.

This same magazine devotes a section to "The Reign of Chemistry." From this industry that has penetrated deeply into our daily lives come plastics. The dental profession early adapted these acrylics to the making of dental prosthesis.

While industry was developing these synthetic products into glamorous items such as Nylons, Orlon, and the latest Acrilan, the dental profession has been content to accept the monotone pink acrylic. Using this one color acrylic, we have fashioned full and partial dentures without regard to the individual for whom they were constructed.

The pride of possession is strong in all of us, and the denture patient of today is not content with the dental prosthesis of yesterday. Like the vulcanite and Hecolite dentures before it, the monotone acrylic denture has come to an end. The sooner the dentist and the technician accept this as a fact, the more readily will the patient consent to oral rehabilitation.

The manufacturer, since the beginning of production of artifical teeth, has attempted to create molds and shades of teeth that would in some respects simulate the natural dentition in appearance. They were and are made in sets of 1×14, and in most instances, used as a unit in full denture prosthesis. At the present, several companies are characterizing individual denture teeth.

Many dentists are endeavoring to create dentures that embody the characteristics of normal dentition. Pound[2], in treating the problem of phonetics by esthetics, tinted the labial and buccal surfaces of his dentures. This created a more natural appearance than other dentures, but its use was limited for lack of skilled artisans. Pound stated, "The upper and lower cases must be waxed up in every detail just as the finished cases are to appear, because practically no polishing can be done, or is required, after they are cured."

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There is a constant demand for a strictly personal denture. This is supported by clinical evidence of diseased teeth retained for no other reason than that the patient hated to face "that false teeth" look. An all-out effort has been made to provide this service.

The author has devoted the past five years to developing a process where finishing and polishing, subsequent adjustments, or relining cannot cause a defect in the characterization. Also, a technique was perfected which permits any dentist or dental technician (under a prescription) to compound these materials into a denture having distinctive individual markings.

COLORS IN GUM TISSUE

An automatic color camera was used to photograph hundreds of mouths. The various reproductions were indexed and studied. It was found by exhaustive tests that the predominating colors were red, light blue, dark blue, brown, and, in some small areas, varying shades of pink.

Mineral pigments were found to be the most satisfactory from every standpoint to provide these necessary colors. The problem of blending the colored polymers into a distinctive feature was not accomplished until color-fast synthetic fibers that could be used to simulate the vascular system were obtained. This also was made possible by modern chemistry.

SHADE GUIDES

The indexed color-blended powders were made into tissue-matching shade guides. As a result of this seemingly endless study, four color-blended powders were found which, by blending, would cover practically all pigmentations encountered. These powders may be used as they are blended, or increased or decreased in percentages as the case indicates. For example, a recent call from an army hospital for a larger supply of brown color-blended powders resulted when there was an increase of Negro troops under treatment.

The story of how to use Colorblend* is well told by the L. D. Caulk Company.[3] They have made this development available to every dentist and technician. However, I would like to present a more detailed description of the technique.

It is impossible for the modern dental office, especially one limited to prosthetics, to function without a most competent technician. I have been fortunate in sharing the services of Mr. La Grande Oglesby, who has worked out the technical details of the ideas and desires for individualized dentures.

It was found that by lamination of thin wafers of the color-blended powders, with the synthetic fibers interspread, a true lifelike denture could be produced. There is no limit to the number of cross blends to reproduce the startling realistic appearance so characteristic of healthy oral tissue.

The technical procedure for characterizing a denture must be preceded by a thorough study of the colors, and their blending, in the oral tissues of the

*This Process is now called "Colorblend." Copyrighted by The L. D. Caulk Co., Milford, Delaware.

patient for whom the prosthesis is to be constructed. As a material aid a set of printed shades is enclosed with each assembly of the Colorblend package. The dentist or his technician may prefer to make Colorblend shade guides similar to the illustrations which permit selections of teeth on colorblended base guide. These shade guides can be sterilized in a solution of Zephiran Chloride.

A diagram in duplicate provided in the assembly must be used so that the dentist and his technician can both check the accuracy of the characterization. Caulk so aptly states, "this forward step in prosthetics will challenge the ingenuity of all persons connected with the construction of a characterized denture."

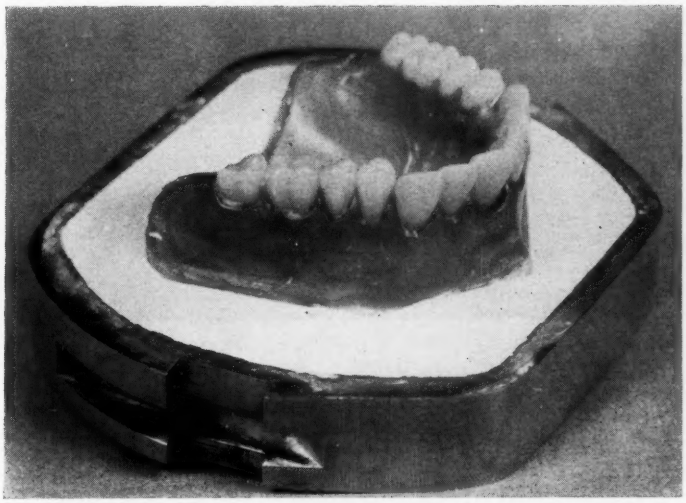


Fig. 1.—The waxed denture invested in the No. 1 flask. (Courtesy of L. D. Caulk Co.)

THE TECHNIQUE

Many technical procedures were tried before a thoroughly practical method was acceptable. This method is now presented with absolute certainty of the result. Each step can be checked, revised and altered as the case requires.

1. The teeth are set up in wax and when tried in the mouth and found satisfactory as to arrangement, the wax may be sculptured approximately, although not necessarily, to conform to the anatomy of the portion to be reproduced. An excess of wax allows sculpturing of the processed denture, permitting the vascular appearing fibers to be revealed.

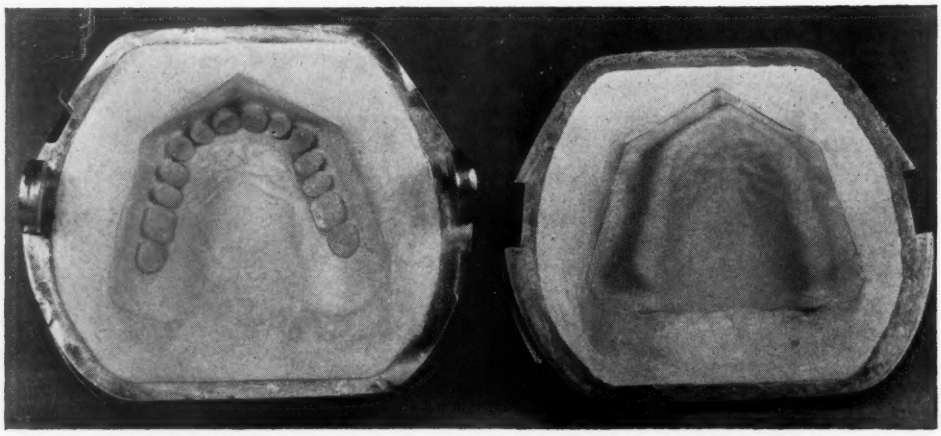
There are various ways of applying the Colorblend and fibers simulating veins, but the most definite procedure requires two flasks that will be designated as No. 1 and No. 2 flasks. No. 1 flask is the flask in which the denture is processed. The supplementary, or No. 2 flask, is for the relief mold and developing the characterized labial-buccal portion of the denture.

2. Invest as for packing an ordinary acrylic denture. (Fig. 1.).
   (a) The periphery of denture is placed level with the edge of the No. 1 flask.

(b) Complete the flasking in the usual manner, i.e., with a plaster middle and a stone cap over the cusps of the teeth.

3. When the investment is completely set, eliminate the wax and clean the mold (Fig. 2).

4. When the flask is at room temperature, mold a wax pattern to the form of the labial and buccal portion of the contemplated denture. This form or pattern is



A. *B.*

Fig. 2.—The clean mold. (Courtesy L. D. Caulk Co.)

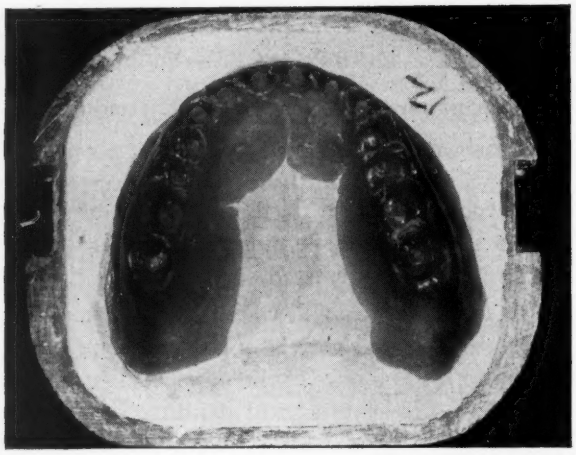


Fig. 3.—The labiobuccal wax form pressed between two sheets of wet Cellophane.

secured by warming and shaping a soft baseplate wax and pressing it into the assembled flask between sheets of Cellophane. This will reproduce the labial portion of the denture to be constructed.

5. Separate the flask and remove the wax form, discard the Cellophane, and cut out the lingual or palatal extension of wax from the form, leaving a horseshoe pattern of the labial portion of the denture (Fig. 3).

6. Fill the cast side of this pattern with plaster and invest it in the No. 2 flask.
   (a) Invest the pattern with the teeth indentations up so the periphery of the wax form is level with the edge of the lower half of No. 2 flask at the distal, and tilted slightly upward at the labial to relieve undercuts (Fig. 4).
   (b) When the plaster is set, trim the wax pattern to remove most of the indentations of the teeth in order to provide room for the gingival

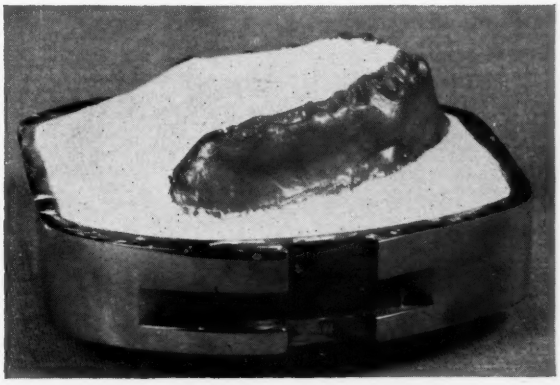


Fig. 4.—The labiobuccal wax form invested in the No. 2 flask. (Courtesy L. D. Caulk Co.)

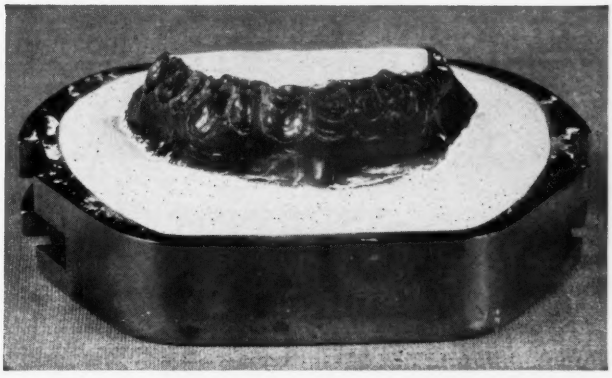


Fig. 5.—Tooth indentations are scalloped out to create space for the gingival coloring. (Courtesy L. D. Caulk Co.)

coloring. Always cut the wax toward the center of the ridge to provide escape gates for the flow of excess Lucitone droplets during trial packing. The wax is scalloped over the gingival area of the teeth indentations to the height required. This varies from the central incisors to the molars in an irregular pattern; i.e. it may be 2 mm. over the central incisor and 5 mm. over the cuspid. The cuspid area usually is the highest and posterior area the lowest (Fig. 5).

   (c) Coat the plaster with a separating medium, and pour the other half of No. 2 flask.

7. Eliminate the wax from the No. 2 flask. Tin-foil both halves.

8. The Colorblend shade, as prescribed by the dentist, is placed in a mixing jar. This may be the Colorblend as provided in individual bottles, or a mixture of one and two (red and light blue), or one and three (red and dark blue), as found necessary for the denture at hand.

9. Mix the required amount of Colorblend powders with the monomer provided (do not attempt with other monomers). (The average denture requires Colorblend powder 16 c.c. and Lucitone monomer 4½ c.c.). Allow the mixture to jell for five or ten minutes into a packing consistency.

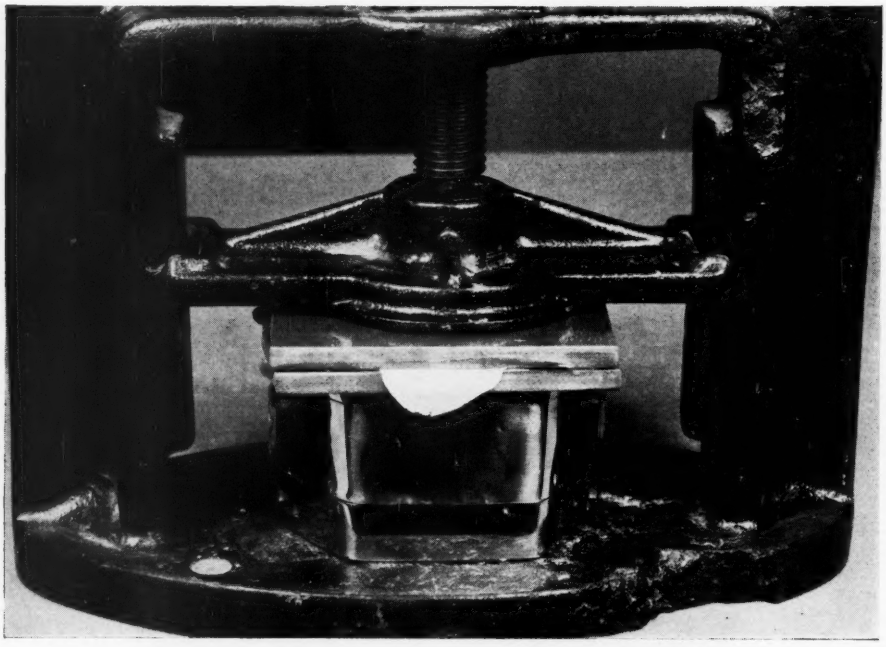


Fig. 6.—Colorblend dough pressed into thin wafers. (Courtesy L. D. Caulk Co.)

10. Remove olive-size portions of the dough from the mixing jar and place them between phenolic resin plates that are covered with wet Cellophane. The plates are placed in a bench press, and the dough is pressed into very thin wafers. Each Colorblend lamination should be pressed tissue thin to have some degree of transparency (Fig. 6).

11. The thin wafers are cut into semicircular strips for the lamination process.

12. The semicircular strips of Colorblend dough are placed on a clean sheet of glass, and tiny wisps of the prescribed colored fibers are tacked to the strips by monomer. To imitate the vascular system, separate the fibers into very small strands.

Sufficient venule simulating fibers must be applied to each lamination so they are visible through the resin and upon the surface of the polished denture. The vein-simulating fibers should always be clearly visible on the denture surface re-

gardless of the depth of sculpturing or polishing. Keep the strips moist at all times with monomer. In order to keep the Colorblend lamination workably soft for easy packing, apply monomer liberally and repeatedly over each layer. Proceed with the above until all but one strip has fibers attached. The majority of fibers should be placed in vertical positions. (Fig. 7).

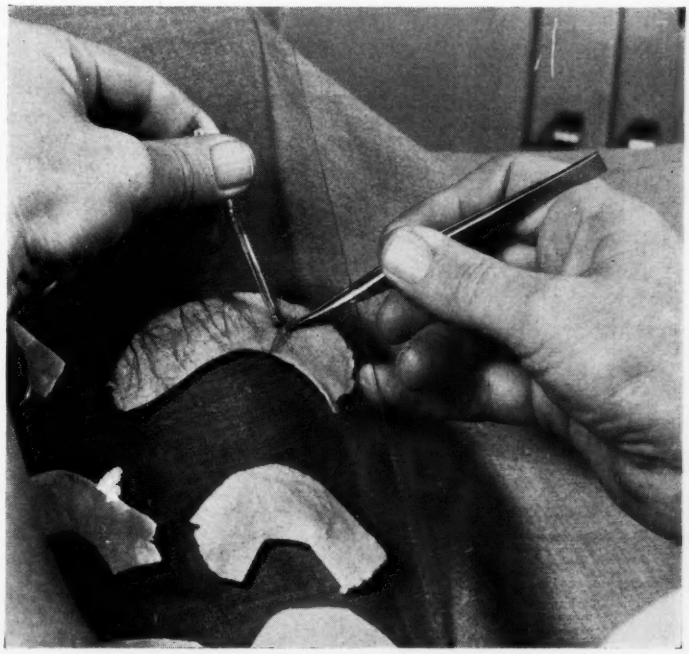


Fig. 7.—Fibers of selected colors are attached to the semicircular strips (Courtesy L. D. Caulk Co.)

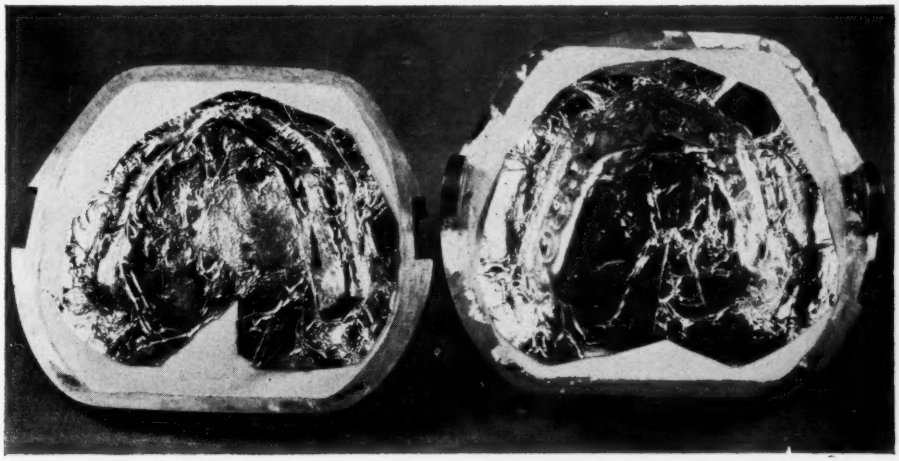
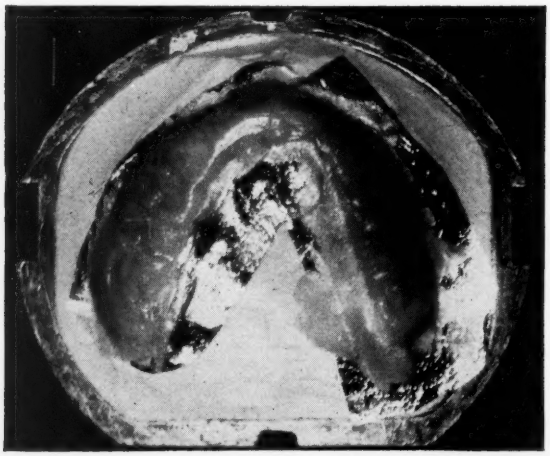


Fig. 8.—Both halves of the No. 2 flask are tin-foiled. (Courtesy L. D. Caulk Co.)

13. Place moistened Cellophane over both tinfoiled halves of the No. 2 flask. (Fig. 8).

14. Pack the horseshoe form by assembling the wafers with the fibers in continued laminations.

N.B. Some races have varying amounts of brown in the mucous membrane. At this stage, very thin portions of brown Colorblend dough can be placed between the lamination with fibers or without as in step 18(a).



A.

B.

Fig. 9.—The strips with fibers are laminated and a test closure is made.

(a) Add strips in layers and compress in the No. 2 flask until it is nearly full. To make the color laminations stick together so that they will not skid during trial packing, press firmly against the layers with the fingers just prior to closing the flask. Tilt the upper half of the No. 2 flask so that it closes first on the anterior area. This prevents the fibers from being displaced and the excess resin will be directed towards the lingual or palatal area (Fig. 9, *A*).

(b) Open the flask and complete the labial and buccal form by covering the cast side of form with wafers without fibers.

(c) Reclose flask and complete the compression of the laminations. Open and remove the laminated form which is now ready for packing in No. 1 flask (Fig. 9, *B*).

15. The half of the No. 1 flask containing the teeth is prepared for final packing by coating it with Alcote.

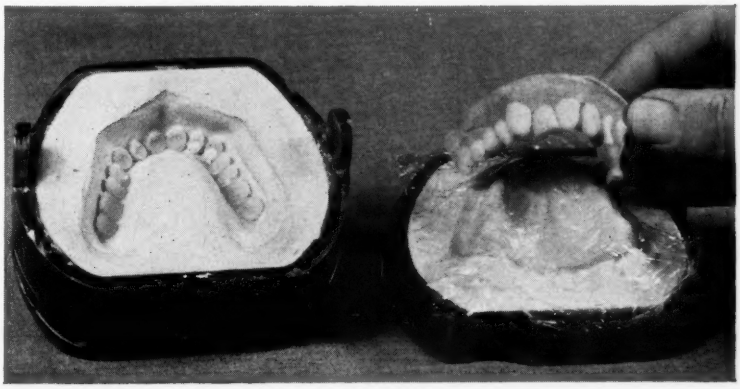


Fig. 10.—Pellets of the desired gingival color are placed over scalloped areas. (Courtesy L. D. Caulk Co.)

16. Mix the required amount of regular Lucitone to complete the packing of the denture and allow it to jell. Mix a very small amount of red Colorblend in a separate jar at this time for creating a separation illusion between the teeth and the base.

17. Place Cellophane over the edentulous half of the cast in No. 1 flask. Remove the Cellophane from the compressed laminated form, and place the laminated form in position over Cellophane covered cast.

18. Complete the packing of the denture by distributing regular Lucitone over the Cellophane covered cast with the laminated form in position.

(a) Place small pellets of Lucitone over the scalloped area to form the gingival area as indicated. At this step, various shades of (pink, blue, brown, etc.) Colorblend may be necessary for individual patients. Place the pellets so the excess material will flow toward the palate or lingual flange (Fig. 10). The red Colorblend is rolled out into

a thin strip and placed in the interproximal spaces following the contour of the invested teeth. This produces a very distinctive area between the teeth and the base.

(b) Close the No. 1 flask by placing the anterior one-fourth of the flask in the press and close it with light pressure. Proceed with the closure in several steps until the flask is completely closed. This will prevent displacement of the Colorblend horseshoe.
After trial packing, inspect the gingival blend of Colorblend by pulling the peripheral border away from the investment. If necessary, remove it to correct blend adjustment. *Do not overfill the flask during the trial packing.*

(c) After the final trial pack, the denture should remain *in press for thirty minutes before starting the cure.* Cure at 160° F. for one and one-half hours, then raise the temperature to 212° F. for thirty minutes. Cool to room temperature, and deflask.

Fig. 11.—A characterized denture. Although the illustration is in black and white it clearly demonstrates the vein-simulating fibers and the distinct gingival color. (Courtesy L. D. Caulk Co.)

19. The surface appearance of the gingival tissue varies according to the individual. In many patients the epithelial layer is thickened and rough, and in others it is smooth. The degree of epithelization will determine the stippling necessary in the gingival areas.

To create an added natural appearance to the denture base, the gingival area may be stippled by a round bur (bent to an off center to a 30 degree angle), to a depth determined by the natural tissue involved. The denture should be polished, stippled, and repolished. This produces countless small depressions that hold small amounts of saliva to add to the natural appearance. Stippling requires a knowledge of anatomy and physiology with an appreciation of form and a true sense of proportion.

The design of the dentures should permit the polished surfaces to be adapted accurately to the muscles of the cheeks, lips, and tongue. This adaptation of the polished surfaces will tend to stabilize rather than disturb the dentures[4].

The completed Colorblend denture, with its true color and vein-simulating appearance, creates a restoration that loses its identity inside the patient's mouth (Fig. 11).

SUMMARY

1. This process of characterizing dentures is founded upon the principles of (a) Adapting laminations of Colorblend resins in the flask so there will be a life-like blending of those colors exposed on the labial and buccal surfaces of the oral tissues. (b) Embedding color fast fibers in the laminations to simulate veins, and hence reproduce the startling realistic appearance so characteristic of healthy oral tissues.

2. The process allows the dentist to construct a denture whose intrinsic worth to the patient sets a high economic value.

3. The colors of the powders and fibers provide innumerable cross blendings to produce any shade indicated or desired.

4. One of the notable advantages of this process is that finishing and polishing, subsequent adjustments, or relining cannot change the characterization.

5. Dentures made by this process permit their anatomic development after processing.

6. The colors of natural tissue can be reproduced so faithfully that partial dentures are no longer a cosmetic problem.

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BRUSH-ON TECHNIQUE IN NATURAL COLORING OF CURED CROSS-LINKED PLASTIC ARTIFICIAL DENTURE MATERIALS

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THERE would be no beauty in the world without color. How well this applies to the art of dentistry. While we cannot improve upon Nature, our ultimate goal is to strive to copy her to the best of our ability, and at least equal the colors that she creates. The ultimate in dental art is to hide the artificiality of dental reproductions or prostheses.

DENTURE TINTING

I have used the heat polymerizing technique of putting natural colors in the veneer of artificial teeth. This has given me the inspiration to carry on with a further development of my own. The original idea was to process polymer powders which contain varying extra pigments into the mold of a flask, and then cure the plastic denture materials in the mold.

After some months' use of the technique described by Pound,[1] I have found that it did not completely fulfill the requirements for a great many patients as to the placement of the natural colors on dentures in their proper location. A development which I believe to be simpler is to apply the tinting material directly to the finished denture after processing. The tinting material is applied directly in front of the patient (Fig. 1). I try to copy each patient's individual tissue color. My method of tinting the finished denture eliminates the difficulty encountered when the thickness of the labial flange causes a protrusion of the lips unnatural to that individual after laboratory processing. When the labial flange is too thick, it has to be ground off, and the color which you have so diligently tried to produce in the laboratory technique is removed. Also, there are no two individuals for whom we can use the same color in the same location. The coloring varies in the mouth of each patient, and we have to individualize the color just as an artist does when he paints a portrait.

EARLY EXPERIMENTS

My first experiments were with fingernail polish and similar materials. However, I found that it would not attach itself to the denture with any degree of permanency. Also, these materials were either acetates or contained acetone as a

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solvent, so they did not bond to the denture well and would wear off easily. The material was inclined to craze the denture materials and some of the plastic artificial teeth. Since the development of cross-linked plastic artificial teeth and denture materials, success has been attained with my technique. This material will not craze the pink plastic materials nor will it craze the cross-linked plastic teeth.

TINTING TECHNIQUE

It is necessary to have the denture form accurately carved in wax. It should be anatomically correct and stippled before processing. Tin foil should be used in processing the acrylic base materials instead of tin-foil substitutes (Alcote). Cross-linked acrylic should be used, if possible.

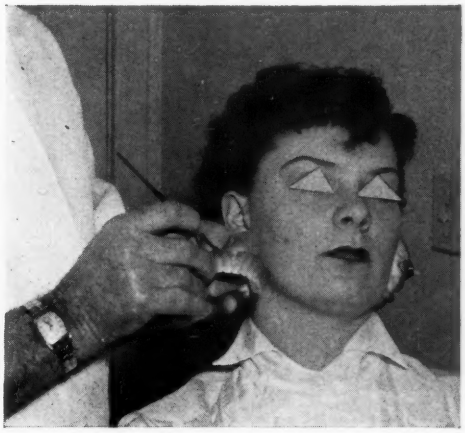

Fig. 1.—Applying Natur-Tint coloring material in front of patient to match the natural color of the tissue.

If the appearance of blood vessels is to be imitated, red Nylon thread which is in three strands is used. Split the strands, and use a single strand. Apply the thread to the labial portion of the mold in the flask, and tack it to place with a paste made of denture-base material. A thin mix of polymer and monomer is used to hold the strands at the desired location. Allow this acrylic to set up in the flask until it is dry. Then pack the base material and finish the denture.

Natur-Tint is the material used for tinting completed denture bases. It is supplied in four solutions. Solution No. 1 is a clear liquid which is used to prepare the surface of the denture base. Solutions No. 2 and No. 3 carry varying amounts of pigment for use on dentures of Caucasian patients. Solution No. 4 is pigmented especially for the dentures of Negro patients.

The technique for tinting dentures is simple.

1. Clean the denture thoroughly. When the new denture is recovered from the flask, it should be shaped and *thoroughly cleaned* but not polished. If an old denture is to be tinted, the high polish should be removed with pumice and rubber wheels.

2. Paint the solution No. 1 (clear) on the outside surface of the labial flange to soften this surface of the acrylic base (Fig. 2). Keep the solution off of plastic teeth and base materials which are not made from cross-linked resins. Allow the solution to soak into the base material for three minutes before applying the pigmented Natur-Tint.

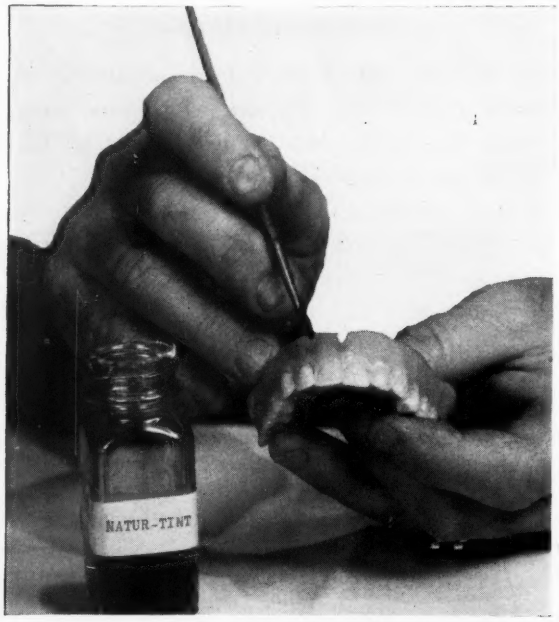

Fig. 2.—Applying Natur-Tint to polymerized acrylic resin denture.

Fig. 3.—*Right,* a denture before tinting: *Left,* after tinting.

3. Determine the pigmented solution to use by comparing the color guide with them. Do not use colors that are too bright. Apply the selected solution to the labial surface of the denture with a small brush. The location and amount of pigment is determined by the location and coloring in natural gum tissue. Two coats of Natur-Tint are applied and allowed to dry for ten minutes.

4. Blend the colors by brushing them with wet flour of pumice. This will remove the glaze which will have formed when the solutions dried after they are applied.

5. Clean and dry the denture and apply two coats of solution No. 1. Allow this to dry for ten to fifteen minutes. This clear solution will cover the pigmented coating with a protective layer of material.

6. Remove the glaze with flour of pumice and a brush. The denture will look more natural if it is not highly polished.

7. The denture may then be inserted in the mouth and the patient dismissed.

I have used this material and technique in my own practice for over a year and have found its use to be very simple. The general practitioner, dental assistant, or laboratory technician can learn to use it easily and quickly. This natural tinting material was developed by the closs-linking of several solvents of acrylic polymer. It can be produced from a sol of monomer and mineral dyes by cross-linking with polymer solvents. A stable tinting material that is noninjurious to finished cross-linked plastics has been developed which will bond itself to finished plastic dentures. It will neither wear off by the patient's brushing of the dentures, nor will it be dissolved by chemicals that may go into the mouth. Colors are available to fulfill the requirements of the patient, and the desire of the technician in his attempt to reproduce the natural colors of the soft tissues of the mouth (Fig. 3). One of these is the bluish brown which is seen in the mouths of Negro people. This technique has been especially valuable for use on anterior fixed bridges and partial dentures where a labial veneer is necessary to restore the lip line or lost tissue. So far as I know, this is the first time anyone has used a plastic coloring material in this form.

SUMMARY

1. A material and method for tinting the bases of artificial dentures to simulate the coloring of natural gum tissues have been described.

2. The simplicity of the technique and the low cost of its application make this a sound procedure in the hands of the general practitioner.

3. The technique can be used in conjunction with the heat-polymerized coloring techniques as an adjunct and improvement.

4. The technique makes possible the production of dentures with a more natural and individualized appearance with a minimum of effort. The results will be appreciated by the patients.

Acknowledgments.—I give credit to the loyal assistance of my technician, Miss Bessie Peterson, in the research and development of colors in the use of this material and in the application of same to the finished dentures.

I also wish to thank Dr. Bruno B. Kielich, Jr., of Buffalo, N. Y. and Dr. M. J. Miller, of Ossian, Iowa, for their assistance and cooperation in this research.

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ALVEOPLASTY WITH TANTALUM MESH

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BOTH the stability and comfort of mandibular dentures depend largely on the size and shape of the alveolar ridge. The use of tantalum gauze has enabled the ridge architecture to be modified favorably in cases of labial and buccal undercuts when it was desirable to maintain the vertical dimension.

Fig. 1.—Note the normal vertical dimension of the lower ridge and the labial undercut.

Fig. 2.—Prominent labial undercut, precluding accurate impression of the ridge.

A 34-year-old housewife was referred on Feb. 20, 1951, by her local dentist for consultation before he proceeded with constructing a new mandibular denture.

The chief complaint was instability and discomfort of a lower full denture of two years' duration.

The patient always had high caries susceptibility, and many of the maxillary and mandibular posterior teeth were extracted ten years ago. The remaining

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Fig. 3.—Tantalum mesh inserted under the mucous membrane filling in the undercut.

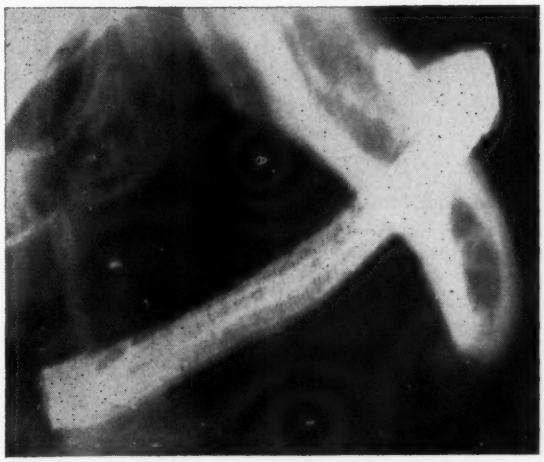

Fig. 4.—Lateral jaw radiograph showing the position of the tantalum.

Fig. 5.—Posteroanterior radiograph.

teeth were extracted three years ago. After her dentures were made she experienced much discomfort with the mandibular prosthesis—it was loose and caused pain in chewing. The maxillary denture was satisfactory.

Examination revealed a well-developed and well-nourished woman who was intelligent and cooperative. She was edentulous, wearing a maxillary denture.

Fig. 6.—Note the obliteration of the undercut. The tantalum mesh can be seen through the mucous membrane.

Fig. 7.—Radiograph one year postoperatively. The dentures have been worn nine months.

She carried a mandibular denture in her purse. The anterior mandibular ridge was somewhat sharp and was characterized by a marked labial and buccal undercut (Fig. 1). Diagrammatically, the prosthetic problem was represented in sagittal section by Fig. 2.

TREATMENT

On March 17, 1951, under intravenous Sodium Pentothal anesthesia, a tantalum alveoplasty was performed. Tantalum mesh was rolled up, and after the

mucoperiosteum was retracted from the mandibular left molar region to the right molar region, the gauze was adapted to fill in the undercut. The tantalum insert was held in place by a few tantalum sutures, and the mucous membrane was sutured over the metal gauze (Fig. 3). Postoperative radiographs are shown in Figs. 4 and 5.

The gauze was well tolerated, and three months postoperatively dentures were constructed. Fig. 6 shows the lower ridge six months postoperatively. Radiographs were also made nine months postoperatively (Fig. 7).

COMMENT

The use of an inert metal such as tantalum which has the chemical properties of glass and the physical properties of steel is particularly well suited to correct prominent alveolar ridge undercuts. This is a technique which may be of great benefit to the prosthodontist.

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INTRAVENOUS ANESTHESIA (PENTOTHAL SODIUM) AS AN ADJUNCT TO IMMEDIATE DENTURE SERVICE

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THE ADVANCEMENT and acceptance of immediate denture service in the practice of prosthetic dentistry has helped to bring about a closer bond of interest and understanding between oral surgeons and prosthodonists. Jordan[1] states, "Complete cooperation between any two branches of a profession such as ours can result only when there is a complete understanding of the problems of each and a willingness on the part of each to aid the other in every manner possible." Immediate dentures or treatment dentures are but a forerunner in the chain of a successive series of dentures in the life of the patient who is to lose his or her natural teeth. The responsibility of the prosthodontist and the oral surgeon as a team is an important factor in this chain.

RESPONSIBILITIES OF THE ORAL SURGEON

The oral surgeon has a threefold responsibility in an immediate denture service.

1. The patient must be shown every consideration for his comfort. The operation to which he or she is to be subjected should not be treated lightly or with a matter of course attitude. It should be borne in mind that the operation is of utmost importance to the patient. The surgeon may have performed thousands of similar operations, but to the patient this is his first venture for surgery in connection with immediate denture service. Even though the patient and the prosthodontist may have had several lengthy discussions on the subject of the new denture, many more questions will require answers by the oral surgeon. The patient also looks to him for security in the undertaking. Reassurance on the part of the oral surgeon will do much toward putting the patient at ease. The patient has every right to be nervous and apprehensive. Premedication to overcome this fear is an important consideration. Care must be exercised by the entire office personnel to work toward a successful completion of the service and for the patient's comfort and safety. Adequate rest rooms are a necessity for the accommodation of patients until their recovery is such as to allow them to return to their homes. Control of bleeding and pain, with proper instructions for aftercare, are of paramount importance.

2. The surgeon's responsibility to the dentist is second only to the patient's comfort and safety. Careful observation of the prescription to be followed on the

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treatment of tissue and bone support, as recommended by the dentist, must be followed to the letter. Failure on the part of the oral surgeon to visualize the problem of the prosthodontist can cause a flaw in the chain of denture service to the patient.

3. The oral surgeon has certain responsibilities to himself. These fall under the heading of requirements that he must request of both the patient and the dentist if he is to assume the responsibility of having a part in the immediate denture service. He must be allowed to select the anesthetic best fitted to the patient. In order to fulfill the dentist's surgical prescription and the proper consideration shown for the patient's comfort and safety, no restrictions on the surgeon's choice of anesthetic agent should be made by either the patient or dentist. The oral surgeon, to warrant this confidence and trust, must be qualified to fulfill his obigations by being proficient in administering general or local anesthetic agents, as well as skilled in surgical judgment. Mead[2] states: "The success or failure of an oral operation may depend upon the correct choice of the anesthetic agent. The choice calls for experience, clear thinking, and good judgment; but at the present it is too often dictated by the fact that the operator has ability in administering only one type anesthetic and, in consequence, all of his patients present indications for the use of that anesthetic. Patients have a right to expect that dentists operating in this field will equip themselves to administer both local and general anesthesia." A thorough knowledge of general anesthesia is essential. Many of the patients referred to an oral surgeon have contraindications for the use of local anesthesia.

NITROUS OXIDE AND OXYGEN ANESTHESIA

A few short years ago the use of general anesthesia was not looked upon with favor for all oral operations. This is particularly true in the field of denture surgery. The reduction of prominent ridges, tori, extensive tuberosities, impacted teeth, etc., could be done with local anesthesia only because of the lengthy surgical procedure. The reason for this singular choice of anesthetic was the inadequancy of the accepted general anesthetic agent, nitrous oxide and oxygen. Successful anesthesia for exacting surgery such as is required for prosthodontic replacements, could not be maintained with this combination of gases. The gases (nitrous oxide and oxygen) if improperly proportioned caused the anesthesia to be carried too deep or too light for surgery. To clarify this statement: the body tissues require oxygen for life. In order to supply the body with sufficient oxygen, one must have approximately 20 or more per cent of oxygen, never less, or cerebral tissue damage can result. When nitrous oxide is combined with 20 per cent oxygen, it gives the patient a mixture of 80 per cent nitrous oxide and 20 per cent oxygen. These percentages are based on the use of a machine calibrated for an intermittent flow of gases. This combination is sufficient only to anesthetize the patient to an analgesic state or semiconsciousness. In order to gain a complete state of unconsciousness using nitrous oxide and oxygen, it is necessary to deprive the patient of life-supporting oxygen. When this condition exists, the patient is in a state of anoxia (tissue oxygen starvation).

The objectionable features of nitrous oxide and oxygen are (1) wild excitement, (2) nightmarish dreams, (3) hysterical laughter, crying, or both, (4) nausea or

persistent retching, (5) cyanosis, because of lack of sufficient oxygen, and (6) excessive sweating. All of these effects arise from lack of the potency of nitrous oxide and oxygen as an anesthetic agent.

Nitrous oxide and oxygen has been the accepted general anesthetic agent of the dental profession for over a century. However, it was looked upon as an agent that could be used only for a short anesthetic period. It was considered good practice in denture surgery (where the removal of teeth and preparation of the ridges were required) to employ "gas-oxygen" for the extractions, then at a later date the alveoplasty was performed under local anesthesia. This same method is obligatory in the one appointment when teeth are fractured, and, because of the inadequacy of the gas anesthesia, it is necessary to resort to local anesthesia to complete the removal of the roots. The "shortcomings" of nitrous oxide and oxygen anesthesia brought much disfavor to it from the professions.

Due to the criticism by the medical and dental profession, many oral surgeons drifted away from the use of general anesthesia and began to develop the field of local anesthesia. To those men who helped perfect the use of local anesthesia should go much praise. Local anesthesia has a place in dentistry, and holds much for the man in the practice of general dentistry. However, to those oral surgeons who realized that surgery of the mouth also required an agent other than local anesthesia, must go the credit for the modern concept of general anesthesia, namely, intravenous anesthesia.

INTRAVENOUS ANESTHESIA

Intravenous anesthesia is, as the name implies, the insertion of a needle into a vein for the purpose of introducing a drug into the circulatory system to produce narcosis. The generally accepted site is the cephalic or median basilic vein which is located in the anticubical fossa. However, when either of these veins are not evident, a suitable vein to act as the vehicle for the drug is selected. The action of the drug is rapid; within a few minutes consciousness is lost by the average individual. During the induction, the patient experiences a feeling of euphoria, which is a sense of well-being. All fear of suffocation, as is experienced with inhalation anesthetics which require a face mask, is totally absent.

INTRAVENOUS INHALATION ANESTHESIA

In the practice of oral surgery today, intravenous anesthesia is used in combination with nitrous oxide and oxygen to produce a fast, pleasant, and safe anesthetic. In anesthesia terminology, this is spoken of as "basal anesthesia." Pentothal Sodium, when combined with nitrous oxide and oxygen, produces a synergistic action to which each anesthetic agent complements the other so as to produce a more even anesthetic. The combination of these three agents makes it possible to use less nitrous oxide and Pentothal Sodium with a greater percentage of oxygen for a smooth anesthetic.

By combining intravenous anesthesia with inhalation gases it is now possible to perform all types of surgery in the mouth without haste and trauma, thereby conserving the tissue and bony support so vital to immediate denture reception.

The accepted method for the application of intravenous inhalation anesthesia is: after the needle is inserted in the vein, atropine sulphate in solution is first injected. One one-hundredth grain of atropine is dissolved in 3 c.c. of distilled water. The use and action of this drug is to dry the mucous secretions in the oral and pharyngeal cavity so as to prevent formation of secretions that can impair the efficiency of the anesthetic and bring on a spasm. After an interval of three to five minutes Pentothal Sodium is injected slowly in amounts of 1.0 to 3.0 c.c. per thirty seconds. The initial dose is given for a tolerance test. If no reaction to the drug is exhibited, added cubic centimeters are given until the patient shows signs of unconsciousness. These signs are the loss of the eye lash reflex, and, as expressed by Thoma,[3] "A noticed separation of the lips, with drooping of the lower jaw accompanied by marked relaxation of the muscles of the jaw as well as of the tongue and of the extremities. The tongue frequently falls back; hence the patient must be watched carefully. The insertion of an adequate air-way removes any obstruction to the breathing from this source." The patient, through the action of the Theo-Pentothal-Sodium, is now in the second phase of anesthesia, having avoided the excitement stage that is characteristic with the use of nitrous oxide and oxygen. As was stated before, the excitement stage is brought on by the patient's fear of suffocation, and by the application of a face mask on a conscious patient. Having rendered the patient unconscious to his surroundings with the intravenous barbiturate, it is possible to induce the individual into the final phase of surgical anesthesia. The intravenous needle is left in the vein to be used for intermittent doses as will be required for smooth anesthesia. The face mask is placed in position and nitrous oxide and oxygen is then given to augment the intravenous drug and to carry the patient to a successful completion of the required surgery.

It is not necessary to hospitalize patients for this service, as it can be done in the modern equipped office where in many instances it can be "done better." Most hospitals do not have the physical equipment that is required for dental surgery. Hospital costs also can be a contributing factor in causing disfavor for this service. The widespread favor of this anesthetic agent among oral surgeons has prompted them to arrange their offices with adequate personnel and sufficient recovery room facilities to meet the needs for their services.

It is rather interesting to note that once patients have been inducted with intravenous anesthesia and experienced the pleasant, heady sensation, it is never a problem to get them to subject themselves for future extractions. Even the most frightened individual will welcome a second experience. This is a definite advantage in immediate denture service where the prescription calls for removal of the posterior teeth at one sitting and the anterior teeth at the final appointment.

Certain immediate denture patients require definite surgical correction. Roberts[4] states, "The advisability of conservative surgery to improve the foundation may be considered, such as the reduction of bilateral bulbous tuberosities which produce opposing undercuts, the removal of pendulous soft tissue, smoothing of sharp, bony ridges, or freeing closely attached frena. All of these complicate the prosthetic problem." Many of these anomalies go uncorrected and dentures are made to circumvent these conditions because of the patient's fear of wakeful sur-

gery, and trepidation on the part of the operator lest the patient be lost by over-insistance for surgery. Horner[5] states, "Timidity is not a solution. The construction of satisfactory dentures is a difficult and complicated procedure and should not be further complicated by the handicap of osseous and soft tissue abnormalities which can be remedied by corrective oral surgery."

FEAR AND ITS CONTROL

Fear of surgery on the part of the patient must be given every consideration, as psychosomatic fear can create an obstacle to denture reception. This fear can and does affect the vagus nerve, and can be a contributing factor in disturbing the progress of the patient from the initial interview to the seating of the finished dentures. Negative response to surgery by the patient and timidity on the part of the operator after viewing study casts showing corrective surgical preparation can be the first step in denture failure. Explanation and education to the patient of the modern concept of anesthesia, namely, intravenous inhalation anesthesia, can be the solution for a more successful denture relationship. Psychic shock and negative responses to surgery by patients can be attributed to "visible pain." This is brought about by the patients being able to see and hear what is taking place at the time of surgery. Coupled with that is "hear-say pain" that is often a topic of conversation over the bridge table. Administration of this type of general anesthesia is at the present time the humane approach toward overcoming these fears.

Some of the patients that undergo the service of immediate dentures are cardiac patients who show definite symptoms. These people can undergo surgery with intravenous anesthesia with greater comfort and safety than with the conventional local anesthesia because of the tension that is relieved on the patient's nervous system by rendering him unconscious to his surroundings. Oxygen percentages, far greater than any other anesthetic agent would allow, can be administered throughout the entire operative period.

Fear of dental pain resulting from surgery keeps more people away from seeking correction of their oral conditions than their lack of education about dentistry. Countless numbers of people will admit that they would have taken care of their mouths if it were not for their fear of dentistry and of embarrassment from the loss of their teeth.

DISADVANTAGES OF LOCAL ANESTHESIA

Local anesthesia alone is not the answer to this problem of overcoming fear of pain. Many people, to use a phrase so often expressed, do not wish to be subjected to the "needle in the gums" treatment. This fact is not the only objectionable feature to local anesthesia for surgery for the insertion of dentures. Pressure anesthesia can result from use of local anesthesia. For example, injections are made for the extraction of the maxillary six anterior teeth. The infraorbital and nasal palatine injections should be used to render the tissues insensible to pain stimuli and avoid the balooning of tissue. However, many operators are not adept with this type of block anesthesia, and resort to labial and palatal infiltration at the apices

of the teeth in the entire anterior segment, which results in distortion of the static tissue. After the teeth are extracted and the denture inserted, the patient does not experience any undue pain from tissue areas that may be subjected to pressure from the peripheral border of the denture. The local anesthetic keeps the terminal nerve endings from sending sensations of painful stimuli to the brain. The denture is allowed to remain in place, and the patient is instructed not to remove the denture until the next office visit. Within a period of from two to three hours, the anesthesia begins to "wear off." The pressure exerted on the denture by the swollen tissue begins to act as a newly injected anesthetic, and the peripheral nerves and blood vessels are crushed causing a pressure anesthesia. This can in turn cause sloughing of the tissue at that particular area. The so-called sore spots under immediate dentures are often caused by pressure of the tissue on the denture while the tissues are under the influence of the local anesthetic. This statement must sound strange, but this is exactly what takes place. The denture does not crowd the tissue because with the present-day impression materials and the ability of prosthodontists to use them, a near static impression can be secured. A definite distending of the tissue by the injection of the local anesthetic can and does happen. The hyaluronic acid in the tissues will not allow for a displacement of the cementing substance in the tissues to allow the permeability of the injected solution. Therefore, the solution injected under pressure must seek space which results in distortion of the peripheral tissues. A denture developed from a static impression seated over this edematous tissue will prove a source of annoyance to the patient and embarrassment to the operator.

Contrast this situation with a proper selection of an anesthetic agent that will not impair tissue response to pain stimuli. Under general anesthesia (intravenous-inhalation), the tissues remain normal; a free flow of blood is constant, nerve stimuli are not interfered with or arrested at the site of the operation following surgery. When the patient regains consciousness, a thorough recheck of the denture can be made. The patient can offer full cooperation by directing the dentist to the areas that feel pressurized. This service can be done when the patient returns to the prosthodontist's office, which is usually one-half to three-fourths of an hour following surgery. However, as many men prefer to accompany their patients and seat the dentures themselves, the necessary corrections can be made in the oral surgeon's office.

ESTHETICS

Esthetics play an important role in immediate denture service. It is frequently for esthetic reasons that the patient agrees to the removal of his or her teeth. Your presentation relative to function, comfort, need for better mastication, vertical dimension, and other important details regarding the finished dentures often go in one ear and out the other. When you talk about esthetics, and point out the fact that the patient need not be without teeth, the picture changes for him, and the presentation becomes more interesting. Your approach should picture satisfaction, happiness, and be a direct appeal to those who judge character by appearance. Since appearance or esthetics of the finished dentures is paramount in the patient's mind, we should do everything in our power to see

that it is carried out. The choice of anesthesia can be the deciding factor by which your denture success will be measured. We know that the use of local anesthesia, whether it be infiltration or block, will cause the lips to appear lifeless. The patient will lose all control of and the function of the orbicularis oris muscle, which is one of the principal muscles of expression. After the teeth are removed and the denture inserted, the patient is unable to experience the thrill of seeing the new denture under natural conditions because of the numb feeling. We are aware of this condition from past experience as a sign of a profound or operative anesthesia. However, to the patient who views the new dentures with the characteristic drooping of the corners of the mouth, plus the possibility of the lower eyelids showing signs of immobility, the picture is anything but pleasant. Constant reminding, "that when the anesthetic wears off you will be better able to see your teeth without using your fingers to hold the lip up" does not always prove satisfactory. We know from past experience of having seen hundreds of immediate insertions that by the time the local anesthetic has begun to "wear off" the tissues begin to swell as a result of the surgery and the hemostatic action of the anesthetic.

Other impressionable failures that often plague the success of immediate dentures to the patient are hematomas and paresthesia. Hematomas can result from injury to a blood vessel by a needle causing an extravasation of blood into the tissues. The ecchymosis is more often into the external facial tissues with immediate dentures to further complicate the cosmetic result.

Paresthesia as a result of injury by a needle puncture is not uncommon. The injection of a local anesthetic into the mental canal for the removal of the lower anterior teeth is often the site of the injury. The patient will complain for several days or weeks, and may not wear the lower denture until this condition is repaired by nature.

It is possible, and not at all improbable, that swelling will result with the use of general anesthesia. However, the patient will have the satisfaction of seeing the finished dentures seated in a mouth free from surgical and anesthetic complications for several hours. The patient's relation to the immediate postoperative picture is of untold value as it bears out your original presentation of satisfaction and appreciation of the finished dentures.

Local anesthesia has left little to be desired as an anesthetic for the surgical removal of teeth or for correction of anomalies that are found in the oral cavity. The patient seldom complains of any pain during surgery provided a good anesthetic is obtained. Yet it is not an uncommon sight to see the patient pass into a state of syncope or convulsive tremors. This condition cannot always be blamed upon the Adrenalin in the anesthetic, as the same people will react in like manner with a solution without Adrenalin. This can be termed "psychic shock." It is brought on, not by any particular drug, but fear of the needle being inserted into the gum tissue. The use of obtundants to allay this fear does not remove this condition, as the obtundant does not affect the mental picture fixed in the patient's mind of what is taking place. It is true that a needle is also used to administer intravenous anesthesia; however, the same patients that go into syncope or

convulsive tremors with local anesthesia show little or no compunctions toward the puncture of a vein. The solution entering the vein meets with no resistance, thereby relieving the mental condition of pressure as is experienced with local anesthesia. Patients today are accustomed to a vena puncture with the drawing of blood for the blood bank and accept it as a matter of course. A sharp needle is a guarantee of success.

COOPERATION

Oral surgeons who administer intravenous anesthesia in their offices are often confronted with a prosthetic problem because of the popularity of the anesthetic. Patients continually present themselves for complete mouth extractions on the recommendation of other satisfied patients who have enjoyed the sensation of going to sleep with a "shot in the arm." Those folks who seek the oral surgeon before consulting the man who is to render their future denture service are, as Terrell[6] states, "going at it backwards." Correction of situations such as this by the oral surgeons is a step toward cooperation between the two services. It is the duty of the oral surgeon to help educate the non-dentist referred patient of the value of consultation with a dentist before the extraction of his teeth. He should stress the importance to the patient of pre-extraction records, casts of the remaining natural teeth, and the relation the ridges will have on his finished dentures. Many of these patients are ignorant of the advancement and perfection that has been made in immediate denture service. Also, many healthy teeth are sacrificed that could be utilized for years in maintaining a partial denture restoration. It is an easy matter for the oral surgeon to determine if the patient has a dentist selected to make his dentures; if not, it is advisable to suggest the names of several men in the patient's community for their selection, and work with the selectee for the best interest of the patient.

Dentistry can be proud of the advancement it has made in its service to the public. Because of the vast field of knowledge that is required to practice all branches of dentistry, we have specialists that not only relieve that burden but bring about a better service to the public. We can do much to improve our standards in the public eye through cooperation and understanding of the various branches of our profession with recognition and respect for their advancements in the science of dentistry.

Intravenous anesthesia plays an important part in the field of prosthetic dentistry, especially as a part of immediate denture service. Through its medium, fear of painful surgery can be eliminated; the nervous apprehensive, the aged, debilitated, and cardiac individuals can be operated on to give them more confidence in our services. More exacting surgery can be performed which will result in a more favorable ridge for the denture support. Everson's remarks on Pentothal Sodium and its merits makes for a fitting closure:

"It is certainly time for the members of the dental profession to accept and use the notable gift presented by modern anesthesiology, Pentothal Sodium, and place nitrous oxide in a position commensurate with its true value, namely, that of a valuable adjunct."

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TWO METHODS OF ADAPTING THE HANAU MODEL H ARTICULATOR FOR USE IN THE TREATMENT OF TEMPOROMANDIBULAR JOINT DISTURBANCES

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DENTAL literature has been singularly profuse recently with articles about the temporomandibular joint. This fact is significant of a definite trend in the nature of dental services. The dentist who wishes to keep abreast of the times must be able to diagnose the numerous cases of temporomandibular joint disturbance which present themselves in his office daily, and to treat at least those cases which are less severe. Brussell[1] says that 57 per cent of the people who are over 23 years of age have two or more clinical symptoms of temporomandibular joint syndrome. My experience tends to indicate that this is an understatement. Sears[2] says, "Somehow dentists have failed to realize how much artificial denture patients suffer from ear lesions and other joint troubles. Though comparatively few case histories are available, routine questioning by a small number of interested dentists and otologists leads to the belief that there are millions of patients suffering unnecessarily from malrelated condyles." As age is not a factor except with regard to frequency, this condition will undoubtedly be seen in every dental office with regularity almost every day.

A great number of works have been published concerning the diagnosis and treatment of temporomandibular joint disturbances,[3] but little has been said about techniques or about the equipment required. Little special equipment is necessary, but there are certain features which are required for the treatment of the more severe or the more difficult cases which are not to be found in the stock models of the articulators which are available at the time of this writing. For our purpose, the Hanau model H articulator has been chosen because of the necessary features which it already has, because it is rather widely used, and because the required changes can be made easily.

In order properly to treat many cases of temporomandibular joint trouble, one would find it a great convenience, if not a necessity, to have an articulator which incorporates two adjustments in addition to those which are regularly found on the better instruments. (1) The operator must be able to adjust the length of the condylar posts, each independently of the other. This represents a vertical change in the positions of the mandibular condyles with reference to the cranium.

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(2) One must be able to move the lower cast anteriorly and posteriorly without changing the position of the upper cast with reference to the hinge axis of the articulator. This adjustment provides for an anteroposterior change of the position of the mandibular condyles with reference to the cranium and to the glenoid fossae. This adjustment is just as necessary as the other one, as it allows certain malrelationships to be compensated for.

It has long been the opinion of many in this field of research that, in unaccustomed hands, an articulator which incorporates the above two adjustments might be a source of difficulty. However, as Sears has shown one with the adjustable condylar posts,[2] and as the one adjustment without the other could be a greater source of difficulty, in our opinion, than the two in combination, the decision

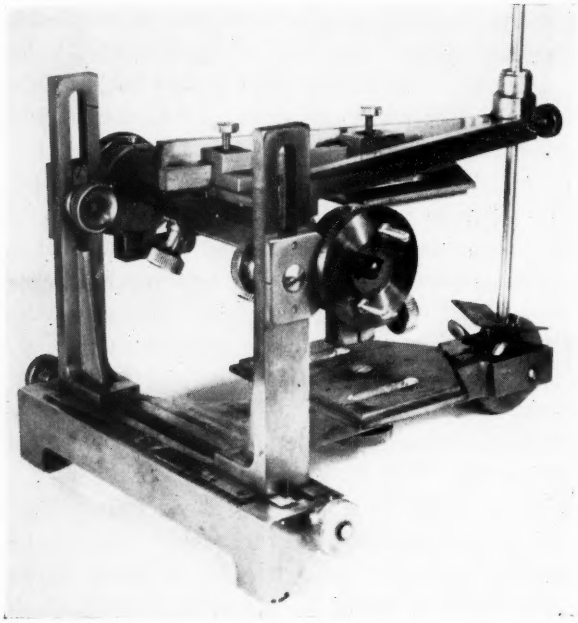

Fig. 1.—The original pilot model articulator designed by T. R. Moore, D.D.S., in 1937. Note the adjustments for altering the distance between the condylar posts, the condylar height, and the position of the upper cast and of the lower cast.

has been made to publish this account. Due to the great prevalence of temporomandibular disturbances among people of all age groups and in all walks of life, and due to the greater amount of information available to the laity[4] and to professional people alike, greater and greater demands will be made upon the practicing dentist to recognise, and in many instances to treat disturbances of this nature. In any case, the positive responsibility to avoid inadvertently and unknowingly causing such serious trouble has irrevocably and absolutely descended upon us. Any one who enters the field of partial or full denture construction or of mouth rehabilitation without being cognizant of the principles and proper technique of mandibular repositioning and the maintainance of proper molar support exposes himself to criticism. The means are herein placed at his disposal.

Fig. 1 shows the original pilot model articulator designed and executed in 1937 by Thomas R. Moore, D.D.S., of the prosthetic department of the Washington University School of Dentistry.[5] It is capable of being adjusted in the manner described. Provision has been made for condylar guidance and incisal guidance. The condylar posts can be moved laterally to compensate for the variations in the distance between the patient's condyles, and a compensatory arrangement has been made so the upper cast can be kept centered. Both the upper and the lower cast can be moved anteriorly and posteriorly. This articulator has been made to receive gnathostatic casts or models and is an excellent instrument for research purposes.

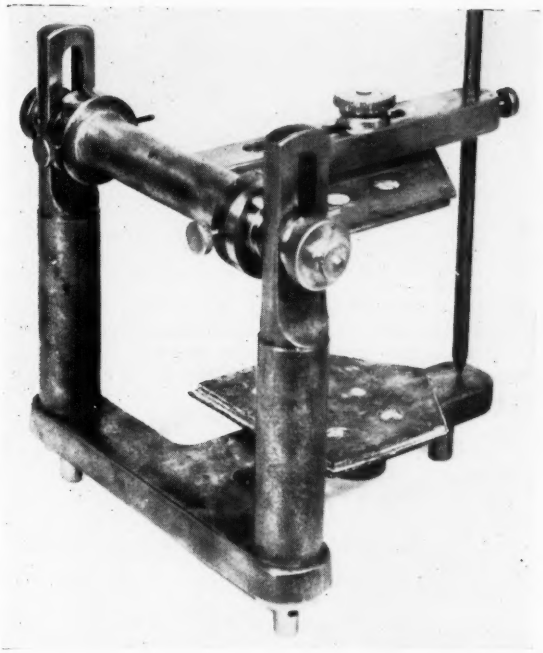

Fig. 2.—This is the simplified version of the articulator designed by Moore. Notice the adjustable condylar posts and the movable mounting stages for casts. Calibrations are on the front of the condylar posts instead of the rear. Condylar guidance is set at zero or horizontal on the articulator as shown, but may be set at any desired angle.

The cost of a number of copies of this articulator would have been prohibitive, so simplified versions were made and have been in extensive use since that time in the department of temporomandibular research.[6] Fig. 2 is a view of one of the simplified copies of Moore's original articulator design. It has the vertical condylar adjustment, and the upper and lower mounting stages can be adjusted in an antero-posterior direction.

At the present time it would be expensive for the individual to have even so simple an articulator as this one custom made in the average machine shop. That is the reason it was decided to alter the Hanau model H articulator so that it could be used in the same manner and for the same purposes. Fig. 3 shows the pilot

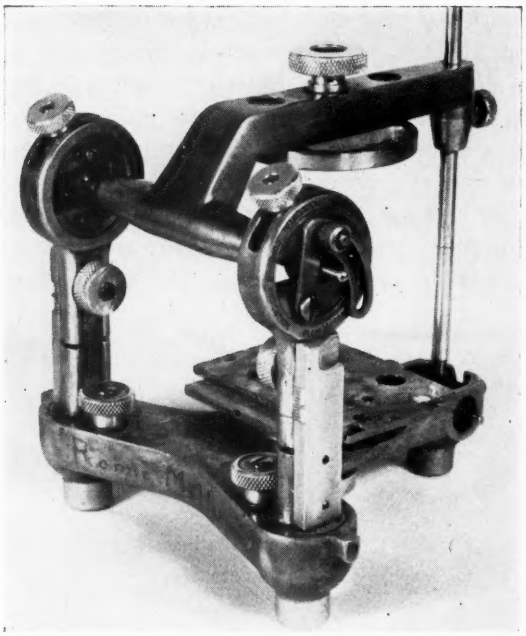

Fig. 3.—The pilot model of the altered Hanau articulator, Model H with the adjustable mounting stage for the lower cast in place. The incisal guide pin has been calibrated in millimeters also. The point where the pin divides has been taken as zero and the calibrations which are above the dividing line are called plus and those below it are called minus. All adjustments on the articulator as shown are at zero.

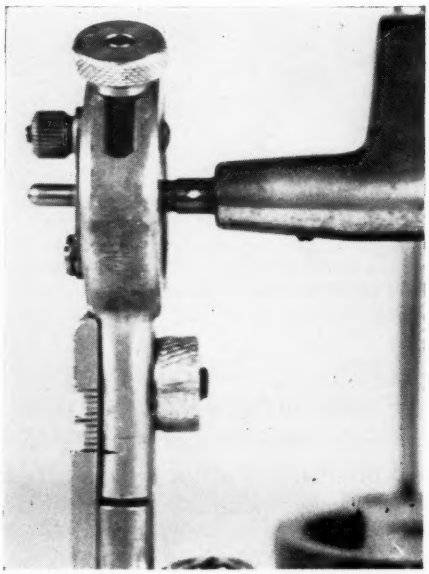

Fig. 4.—This is a detailed view of the left condylar post of the pilot model Hanau articulator, Model H. Calibrations up to ten millimeters have been adequate, as the greatest amount of condylar change or change in condylar position I have ever successfully given any one patient at any one time is nine millimeters. This statement holds true for several hundreds of cases. Additional calibrations may be added if desired.

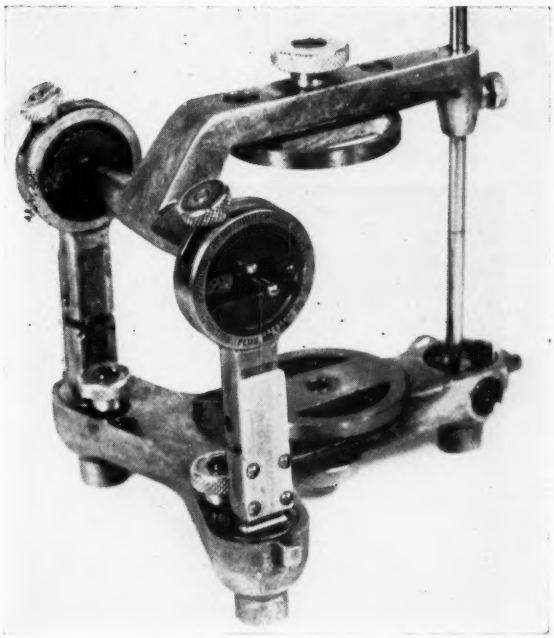

Fig. 5.—The second Hanau Model H articulator. The condylar posts have been divided to provide for change in the positions of the mandibular condyles. The adjustable mounting stage for the lower cast should be substituted for the standard Hanau mounting ring shown here.

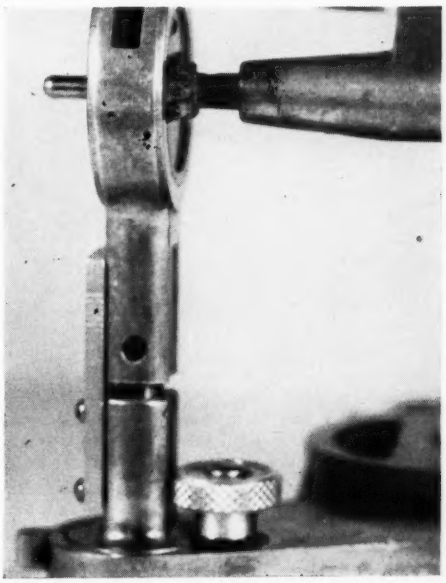

Fig. 6.—The condylar post is set at plus two millimeters in this view of the second Hanau Model H articulator. Notice the set screw and the central reinforcing rod. The reinforcing rod would be concealed if the condylar adjustment were set at zero.

model H which has been in use in its altered form since 1947. This is an older articulator, and the condylar posts are solid. These posts were cut in half and the outer side of each half was rabbetted or routed out to provide a channel. Into this channel was inserted a member which was bolted to the lower half of the

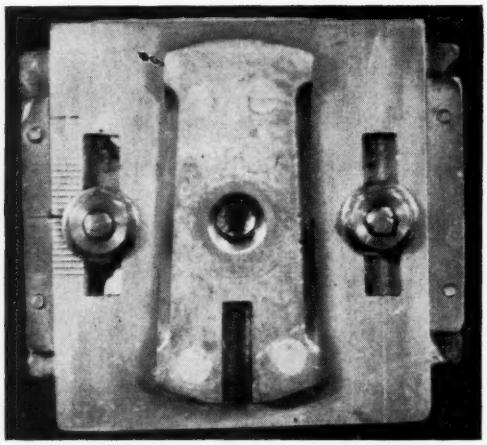

Fig. 7.—The adjustable mounting stage for the lower cast in detail. The adjustable part has been riveted to the middle portion of a standard Hanau mounting ring so the whole assembly may be fastened to the lower stage of the Hanau Model H articulator in the usual manner.

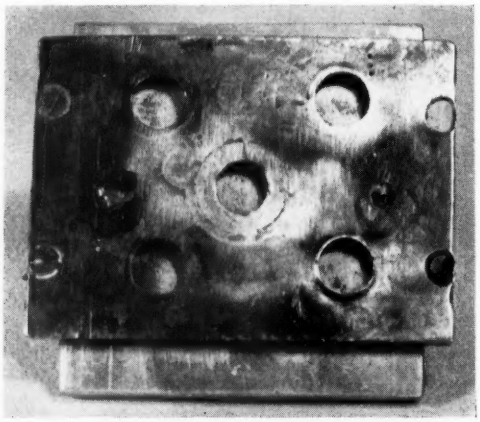

Fig. 8.—Holes have been drilled and countersunk from the reverse side of the brass mounting plate shown here on the top of the adjustable mounting stage assembly. The plaster of Paris which holds the lower cast in place is retained by these holes.

condylar post. Adjustment of the upper half of the condylar post was provided for by the addition of an Allan screw, a washer, and a knurled nut, as shown. The posterior aspect of the upper half of the condylar post was then calibrated in millimeters so accurate adjustments and records could be made. Fig. 4 shows in detail how the parts were assembled.[7]

The second method of alteration is adaptable to the newer Hanau model H articulator, the condylar posts of which have been hollowed out to receive a central reinforcing rod. In this instance the condylar posts were removed from the base of the articulator and from the central reinforcing rods and were cut in half. The posterior or back of the reinforcing rods was faced off ever so slightly to allow for the passage of air and for fixation of the upper half of the condylar posts which were drilled and tapped to receive a set screw. A flat plate of one-eighth inch aluminum alloy was bolted on to the lateral or outer face of the lower half of each post so that the two halves could be kept in alignment and to provide for calibration as shown in Fig. 5. Fig. 6 shows in detail how the change was made.[8]

In order to avoid frequent remounting of the lower cast, it was necessary to devise a way of adjusting its position anteroposteriorly. The sides of a standard Hanau mounting ring were cut off and the remaining central member was riveted to a square piece of one-eighth inch aluminum plate. A mounting plate of one-eighth inch brass was devised with flanges to fit as shown, and was bolted to the aluminum plate. Calibrations, again in millimeters, were added as a final step. This reduces the space available for mounting the lower cast by one-fourth inch, but in practical use the loss of space has not been noticed. Figs. 7 and 8 are detailed studies of the adjustable mounting stage for the lower cast. No provision has been contemplated for adjusting the position of the upper cast on the altered Hanau articulator, as gnathostatic methods are no longer used in diagnosis of temporomandibular joint troubles either in clinical or in private practice.

I wish to acknowledge with thanks the aid and assistance rendered by Peter T. Barrett, B.S., M.E., in the design and execution of the alterations made in this articulator.

I wish to express my gratitude to A. W. McLean, D.M.D., who designed and made the adjustable mounting plate and the changes in the second articulator.

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BOXING AN ALGINATE OR HYDROCOLLOID IMPRESSION

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AN ALGINATE or hydrocolloid impression is much easier to box and pour if a narrow strip or bead of boxing wax is placed around the outside of the tray *before* the impression is made. Hydrocolloid should be loaded into the tray

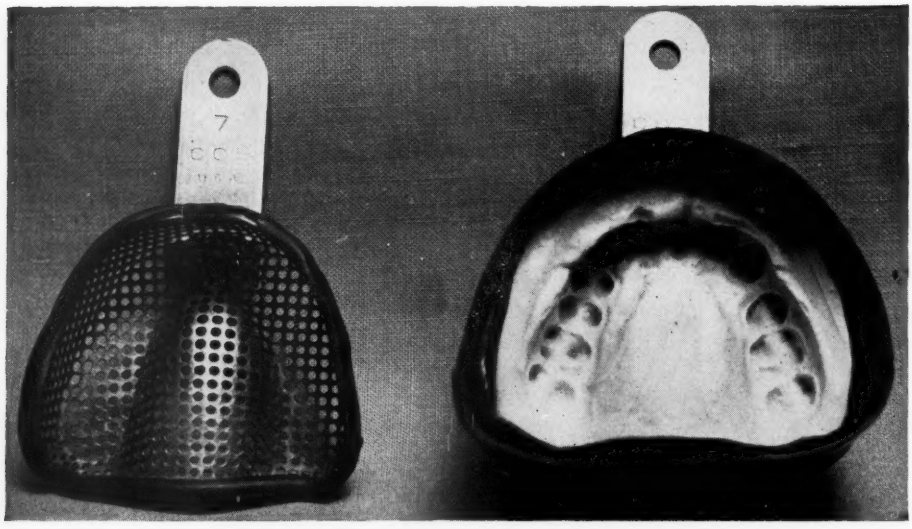

Fig. 1.—*Left,* tray with wax strip or bead. *Right,* impression boxed.

at the tempering stage so the wax will not distort. The thin flash of excess alginate or hydrocolloid that flows over the bead is easily removed with a sharp knife so the boxing strip may be luted to it.

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A COMPARISON OF TOOTH-BORNE AND TOOTH-TISSUE-BORNE REMOVABLE PARTIAL DENTURES

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A PARTIAL denture may be defined as any removable prosthetic restoration which replaces missing teeth in a partially edentulous dental arch. Strictly speaking, however, a partial denture is a prosthetic restoration which *derives its support principally from the tissues underlying its base,* and only to a minor degree from the remaining natural teeth which are used as abutments.

Where there are remaining natural teeth, which we may use as abutments, both anterior and posterior to the edentulous area, we still speak of such a prosthetic restoration as a partial denture. However, such a restoration is actually a removable bridge, even though it is bilateral in extent. This is true because the restoration derives its support from two or more remaining teeth through the placement of occlusal rests on those abutment teeth. The tissues underlying the base or saddle of this removable-bridge type of partial denture do not contribute appreciably to the support of the restoration.

Thus it may be seen that two distinctly different types of partial dentures exist. For better understanding, let us refer to these two types according to the classification of partially edentulous arches set forth by Kennedy some twenty-five years ago, and which has not been materially improved upon since.[1] Probably the most important advantage to this method of classification is that there exists a definite relationship between each Kennedy class and the principles of partial denture design which apply to that class. The Kennedy classification is as follows:

Class I —Those cases having bilateral edentulous areas located posteriorly to the remaining teeth.

Class II —Those cases having a unilateral edentulous area located posteriorly to the remaining teeth. (Additional edentulous areas are modifications of this class.)

Class III—Those cases having a unilateral edentulous area with teeth remaining posterior and anterior to it. (Similar additional endentulous areas are modifications of this class.)

A fourth class, Class IV, deals with those cases having a single edentulous area crossing the midline located anteriorly to the remaining teeth. For purposes of simplification, however, only the first three classes will be considered here.

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Certain points of difference exist between the first two types of partial dentures and the Class III, removable-bridge type of partial denture.[2] First, let us consider the manner in which each is supported. The Class I and the free-end side of the Class II derive their support from the tissues underlying the base, and only to a minor degree from the abutment teeth, whereas the Class III derives all of its support from the abutment teeth situated at either end of the edentulous area.

Secondly, for reasons related to the above, the method of impression registration required for each will vary with the source of support.

Thirdly, a need of some provision for indirect retention exists in the free-end type of partial denture, whereas in the tooth-borne type there is no free-end base which may lift away from the supporting tissues due to the action of sticky foods and movements of the tissues of the mouth against peripheries of the denture. Each saddle being retained by attachments both anterior and posterior to it, the tooth-borne partial denture does not require indirect retention.

DIFFERENCE IN SUPPORT

The partial denture, since it derives its major support from an elastic, fibrous connective-tissue covering over the residual alveolar bone, is dependent upon the quality of that support for its stability under functional stresses.[2] Some areas of this residual ridge are firm, with limited displaceability. Other areas are very displaceable, depending upon the thickness and structural character of the tissues overlying the residual alveolar bone. The movement of the base under the stresses of function determines the degree to which the stress load is magnified by leverage.

IMPRESSION REGISTRATION

An impression registration for the construction of a partial denture must fulfill two requirements: First, the anatomic form and relationship of the remaining teeth in the dental arch, as well as the surrounding soft tissues, must be recorded so that the prosthesis will not exert any pressure on those structures, and so that its retentive and stabilizing components may be placed properly. Some impression material which can be removed from undercut areas without permanent distortion must be used to fulfill this requirement. Hydrocolloid impression materials are almost universally used for this purpose.

Second, the supporting form of the soft tissues underlying the base of the partial denture should be recorded so that firm areas are not overloaded and softer areas are made more compact and capable of supporting their share of the total work load. Only thus can maximum support of the partial denture base be obtained. An impression material which is capable of displacing tissue so as to register the supporting form of the ridge will fulfill this second requirement. Such an impression material is Kerr's Korecta Wax No. 4. (Korecta Wax No. 1 is also used, not as an impression wax but as a tray material.)

There is no single impression material available up to the present time which can fulfill both of the above requirements. To compromise by recording only the

anatomic form of both teeth and supporting tissues as is all too frequently done, can result only in inadequate support for the partial denture saddle.

DIFFERENCES IN CLASP DESIGN

A fourth point of differences between the two main types of partial dentures lies in their requirements for direct retention. A direct retainer may be either intracoronal or extracoronal in type. Only the extracoronal type, commonly known as the clasp-type direct retainer, will be considered here. These may be classified on the basis of structure, such as cast, wrought, or a combination of both. They may also be classified on the basis of type, such as circumferential or bar type.

The tooth-borne saddle, having abutment teeth at either end, may be retained and stabilized by clasps whose only function is to deform sufficiently during the insertion and removal of the restoration to allow them to flex over the height of contour of the teeth in passing to and from an undercut area. While in its terminal position on the tooth, the retentive clasp is not called upon to flex, other than to engage the undercut area of the tooth for the purpose of resisting vertical movement.

Cast retentive arms are usually used for this purpose. These may be either of the circumferential type or of the bar or so-called Roach type which arises from the base of the denture and approaches the undercut area from a gingival direction. Each of these two types of cast clasps have their advantages and their contraindications.

The direct retainer for the free-end saddle must perform still another function, in addition to that of resisting vertical displacement. Because of the absence of distal support, the saddle will move tissueward under function proportionate to the quality of the supporting tissues and the accuracy of the supporting base. Therefore, those elements of the clasp which lie in an undercut area must flex sufficiently to dissipate the stresses which would otherwise be transmitted to the abutment tooth as leverage.

The cast clasp cannot act effectively to dissipate this stress by flexing, for two reasons; first, the material itself can have only a limited flexibility, or else other parts of the casting, which must be rigid, such as lingual and palatal bars, would also tend to be somewhat flexible. The material being the same, the only variable factor, then, is the bulk and diameter used in the clasp design.

Second, and probably more important, the cast clasp is of necessity made half-round in shape. Since edgewise flexing is negligible, it can flex in but one direction, and therefore cannot effectively dissipate, by flexing, all stresses placed upon it. For this reason, most of the tilting stress is inevitably transmitted to the abutment tooth as leverage.

Immediately there comes to mind the stress-breakers which are often incorporated into the partial denture design for this very reason. There are those who strongly feel that stress-breakers are the best means of controlling stresses on the abutment teeth. It is just as strongly felt by others that the wrought wire retentive arm more effectively accomplishes this purpose. It cannot be denied, however, that

a retentive arm made of wrought wire can flex more readily in all directions than the cast half-round arm, and thereby more effectively dissipate those stresses which would otherwise be transmitted to the abutment tooth.

Perhaps a bit of clarification is needed at this point. Only the *retentive* arm of the clasp should be made of wrought metal. Reciprocation and stabilization against lateral movement must be obtained through the use of rigid cast elements making up the remainder of the clasp. This has been called the combination-type clasp, being a combination of cast and wrought materials incorporated into the design of the direct retainer.[2, 8] It is used most frequently for the free-end partial denture. However, the combination clasp has advantages of adjustability, minimal tooth contact, and other advantages, which, in addition to its flexibility, makes its use for tooth-borne appliances at times desirable.

THE CLASS III, REMOVABLE-BRIDGE TYPE OF PARTIAL DENTURE

The Class III, removable-bridge type of partial denture, being entirely tooth supported, may be made to the anatomic form of the teeth and surrounding structures. It therefore does not require an impression of the functional form of the tissues underlying the saddle.

It does not require indirect retention, because each terminus of the saddle is secured by a direct retainer against movement of the base away from the tissues. Should a tooth not be suitable for such direct retention, as, for example, an upper lateral incisor, then the denture must be considered to be tooth-tissue borne. In such case an impression of the functional form of the ridge must be recorded to provide for tissue support of the base, and indirect retention must be provided.

Cast clasps of either the circumferential or bar type must be used, or the combination clasp may be used by preference.

The tooth-borne partial denture is frequently an important adjunct to periodontal treatment by its stabilizing influence on the remaining teeth in the dental arch.

THE CLASS I, BILATERAL, FREE-END PARTIAL DENTURE

The Class I, bilateral, free-end partial denture is just about as unlike the removable-bridge type as any two dental restorations could be. Since it derives its principal support from the tissues underlying its base, a Class I restoration made to anatomic ridge form cannot have uniform and maximum support. Yet a majority of Class I partial dentures made today are made from hydrocolloid impressions. It is small wonder that many partial dentures have given their wearers only brief service, followed by the extraction of the remaining teeth. Not only do the abutment teeth and supporting tissues suffer, but the occlusal stresses placed upon the remaining teeth are increased by the lack of posterior support.

THE FLUID-WAX IMPRESSION

The fluid-wax impression material is the only material available at the present time which can accurately record the supporting, or functional, form of the eden-

tulous ridge. This is usually accomplished by using the metal casting as a medium for carrying the impression waxes to the mouth, and then relating this temporary wax base to the remainder of the master cast.

The completed wax impression is used to correct the ridge areas of the master cast by returning it to the master cast, from which those areas have been cut away, and repouring the ridge areas with a new mix of stone.

ESSENTIALS OF DENTURE DESIGN

This method of recording the supporting form of the ridge necessitates the making of the cast framework prior to the correction of the ridge areas to their functional form. The denture design should be carefully planned and outlined on an accurate study cast. Following the making of necessary mouth changes to provide for occlusal rests and guiding planes, the master cast is made and carefully surveyed to determine the location of undercut areas which are to either be blocked out or utilized for retention. The denture is designed to provide for occlusal rests and rigid reciprocal arms on all abutment teeth, to assure occlusal and lateral stability of the restoration.

The denture planning and design must include provision for adequate indirect retention which will function to counteract any lifting of the free-end base away from the tissues. The indirect retainers should be placed in relation to a line drawn through the occlusal rest of the two principal abutments. This is the axis of rotation, or the *fulcrum line*. It may take the form of an auxiliary occlusal rest, a secondary lingual bar in combination with a terminal rest, a lingual plate with terminal rests at either end, or an incisal hook on an anterior tooth.

Some retentive lugs for the attachment of the impression waxes, and later the resin saddles, must be provided for, to complete the denture design. Eighteen or nineteen-gauge wrought wire of some suitable alloy is then waxed into the body of the clasps, which will later be adapted to the tooth as the retentive arm of the combination clasp. Ney PGP round wire has proved to be suitable for this purpose when a low-fusing chrome alloy such as Ticonium is cast to it. However, it is necessary that it be attached to the casting by soldering where one of the higher-fusing chrome alloys is used.

Eighteen-gauge round Ticonium wire has also been used successfully, with some evidence of greater durability than the PGP wire. It is a little harder to adapt, but does not nick so easily during adapting, and seems to be less easily distorted by careless handling on the part of the patient.

Fitting of the finished casting back on the master cast is made easier by the use of combination clasps, for until the wrought retentive arms are adapted, any resistance to the seating of the appliance must be interference, and the casting is relieved accordingly.

The casting completed, the wax functional impression is made, and the master cast is corrected as previously outlined. The establishment of the occlusal relationship and the adding of the teeth and base to the casting follows.

THE CLASS II PARTIAL DENTURE

The Class II partial denture is actually a combination of tissue-borne and tooth-borne restorations. How right Kennedy was when he placed this class between Classes I and III, because it embodies features of both. The free-end base should be made to functional form, whereas any modification spaces, which are tooth-borne, are made to anatomic ridge form. Indirect retention must be provided for, but usually the anterior abutment on the tooth-borne side can be made to fulfill this requirement. If additional indirect retention is needed, it must be provided.

Cast clasps can often be used on the tooth-borne side, whereas the wrought combination clasp is needed on the free-end side. However, careful case planning may reveal a need for combination clasps on all abutment teeth.

The cast framework is usually used as a carrying medium for the fluid-wax impression materials, in the same manner as for the bilateral free-end case. Only the edentulous ridge on the free-end side is recorded in its functional form; consequently only that portion of the master cast is reproduced.

THE METAL-BASED PARTIAL DENTURE

The metal base has many advantages over the resin, or acrylic, base. The sole disadvantage to its use in the posterior part of the mouth lies in the fact that it can be relined only with difficulty, if at all. Nevertheless, the stimulation that it gives to the underlying tissues is so beneficial that it probably prevents some alveolar atrophy that would otherwise occur under a resin base.

The Class III, tooth-borne type of partial denture base may be routinely made of metal so long as requirements of esthetics do not prevent its use. However, the technical difficulties involved in the making of a one-piece metal-base partial denture to the supporting form of the edentulous area have, in the past, restricted their use in free-end types of partial dentures.[4]

More recently[5], this problem has been successfully solved by the utilization of an acrylic tray made with three definite occlusal stops. This assures the seating of the tray both in the mouth and back on the master cast with equal accuracy.

After the wax impression is made in this acrylic tray, it is seated back on the master cast from which cast the ridge areas have been removed, and attached to it securely with sticky wax. The saddle areas are thus corrected to their functional form. The resulting master cast, complete with corrected saddle area, is then ready for the construction of a metal-base partial denture, the free-end saddle of which will be made to the supporting form of the edentulous ridge.

Thus it may be seen that there are two distinctly different types of partial dentures. Unfortunately, not all partial dentures are tooth-borne. If such were the case, our problems in the restoration of missing teeth in the partially-edentulous dental arch would be much more easily and successfully solved.

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MASTICATORY FUNCTION OF PARTIAL DENTURE PATIENTS AMONG NAVY PERSONNEL

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THERE HAVE been few objective studies concerning the extent to which partial dentures can restore the masticatory function of patients with missing teeth. In 1922 Schutz[1] described results obtained with one patient for whom a special partial denture was constructed. Individual teeth were removed successively from the denture, and tests were made on masticatory ability of the patient after each change of the denture. Zwieback was employed as a test food, and the chewed food was sieved on two screens, dried, and weighed. The food dissolved was used as the criterion of efficiency in the mastication. By this criterion the performances of the deficient and efficient dentitions were 37 and 50 per cent, respectively, with bicuspids exhibiting half the value of molars in restoring masticatory function. When Schutz's data were recalculated by one of us (R.S.M.)[2] using as a criterion the percentage of food passing either screen in accordance with recent concepts, Schutz's conclusions could not be substantiated.

Eleven years later Gelman[3] made an experimental approach to the question of improvement in mastication by means of partial dentures. His measurement of masticatory capacity was based on the degree of pulverization of almonds by a standard masticatory effort. There were eleven cases of full or partial dentures studied, six of whom were tested before and after the partial denture had been inserted. Two-thirds of the latter showed improvement in their masticatory capacity, but since the final capacity of these patients ranged from 22 to 97 per cent, very little could be proved concerning the relative merits of different types of partial dentures because of the small number of patients.

It appears to the authors that these early workers were handicapped by insufficient basic knowledge concerning masticatory efficiency. They could not be certain as to which foods to select for test in order to be representative of a normal diet,

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whether or not to confine mastication to one side of the mouth, how to collect, screen, and measure the quantities of food obtained on different screens, or how to interpret the conflicting findings from various screens. Perhaps it is well that extensive studies were not undertaken at that time. Now that the basic knowledge has been accumulated, it is probable that we know what should be measured and how the measurements should be made.[2, 4, 5]

These principles were applied recently to a study of the better function which results from a removable or fixed replacement of the first permanent molar.[6] Masticatory efficiencies of 20 patients were tested with both hard and soft foods. There was an immediate increase in efficiency and a learning period of at least two weeks. On the average the patients were induced to pulverize their food finer before swallowing, and to obtain this better pulverization with fewer masticatory strokes.

The general purpose of this investigation was to obtain information on the masticatory function of partial denture patients before and after completion of prosthetic restorations. The approach was designed to disclose the relative impairment in function among patients who had been designated as needing partial dentures, and the extent to which normal function is restored by the appliance. Tests were repeated in order to learn whether function improves as the patient gains experience in using the appliance. Patients were selected in different categories in order to allow some comparison of the relative merits of free-end versus tooth-supported partial dentures, of partial dentures replacing different numbers of types of missing teeth, and of appliances occluding against natural and artificial dentitions.

Several measures of function were recorded at each sitting for the right and left sides of the mouth, hereafter referred to as half dentitions. Maximum biting forces were determined for teeth which would be used as abutments for the partial denture, using the Howell-Manly[7] oral force meter. The food platform area was determined by the Yurkstas-Manly[8] technique for each half dentition. Masticatory performances were determined for each side of the dentition by the Yurkstas-Manly procedure, and this figure was converted to masticatory efficiency from a published table.[2] This procedure employed peanuts as a test food. In studies on the first 50 patients raw carrots were also used as a test food in order to have representatives of both soft and tough foods.* Among these patients the correlation coefficient between the two procedures was quite high (0.9). This indicated that masticatory performance was similar, whether measured by a soft or a tough food, and that the less convenient test with carrots could be eliminated. All findings reported, therefore, are based on tests with peanuts.

Patients were also requested to chew three gram portions of peanuts until they considered the food to be ready for swallowing, and observations were made concerning the number of strokes required. The percentage of the food passing the 10 mesh screen represents the fineness of the foods at the swallowing point (U_p)

*Previous studies[5] on 35 foods had shown that peanuts were representative of soft foods, and carrots should be classed as one of the tough foods.

and the number of strokes (S_p) indicates the relative effort required to prepare food for swallowing.

The subjects were recruits at the Great Lakes Naval Training Center who had been designated as requiring prosthetic treatment. Dental records, personal histories, and function tests were made on the subjects before surgery was performed, before and after insertion of dentures, 10 days later, and 30 days later. Efforts were made to obtain similar numbers of small, medium, and large partial dentures and fairly equal distribution of partial dentures occluding against artificial and natural dentitions and of partial dentures which were free-end and tooth borne.

DETAILS OF METHODS

The first examinations and tests were performed on patients before any restoration or dental surgery had been performed. Such readings represent the condition of the patient as he entered the Navy. An H-4 Navy dental record was made at the original dental examination, showing missing teeth, restorations present, dental caries, and teeth to be extracted. On a second chart of the same form were marked the replacements which the patient received at a later date, including notations as to type and mold of teeth employed. Another chart included the patient's number, name, age, height, weight, race, home state, side preferred for food mastication, tooth mobility, gastrointestinal complaints, periodontal pockets, alveolar bone loss, gingival recession, and painful teeth.

The partial dentures were constructed with cast gold skeletons, with acrylic bases and porcelain teeth. Posterior teeth were the 20 degree type modified to harmonize with the patient's occlusal pattern. The usual laboratory procedures were used for processing. All full dentures were spot ground on the day of insertion and about half were remounted on the articulator and ground into occlusion. The occlusions were checked on the fourth day after insertion.

The investigation was a cooperation using the facilities available to one of us (L.F.A) and the background knowledge available to the other (R.S.M). The program was conducted at Great Lakes Naval Training Center by the author under the supervision of Captain Pitton. Data were compiled and analyzed at Boston.

RESULTS

The amount of information obtained in this study made interpretation a major problem, especially since there was so little information in the literature that could guide our interpretation. There were over 100 patients who were tested at each of five different periods, making a total of over 500 sittings among the group of patients. At each sitting, between nine and ten measurements were made on each patient, making a total of about 5,000 items. In addition there were 30 partial denture patients who had used their denture for a period of nine months or more, on each of which four observations were made. Studies on 108 full upper and lower denture patients, adds about 430 more measurements, and tests with carrots as a test food brought the grand total to 5,500 items of data.

The first requirement of analysis was to select a criterion by which the influence of the variables would be judged. For this the efficiency of the partial denture patient at the one month period was chosen. An alternative yardstick was improvement in efficiency, but this criterion was not used since it seemed logical to assume that the goal of dental restoration is to bring chewing efficiency back to normal, rather than just to show a gain.

Some of the partial dentures came into occlusion against a natural dentition and others against a full denture; some were free-end and others were tooth-borne; some added merely a premolar, and others added two premolars and two molars to the teeth in occlusion. The problem of interpretation was how to sort out the influence of each of these three variables—(1) type of occluding dentition, (2) type of partial support, and (3) the size of the partial denture—when there was the possibility of two effects working together in some groups.

The patients were first divided according to whether the partial denture occluded against a natural or artificial dentition. Each of these groups was further subdivided according to the number and position of the occluding teeth which were added to the dentition by the partial denture. This was not always the same as the number of teeth on the partial denture; for example, a lower partial denture bearing the second premolar and first and second molar might add only a second premolar and second molar to the dentition because of a missing upper first molar. When the one month efficiencies were examined for partial dentures occluding against an artificial dentition (type A), there was no indication of superiority for any particular group of partial dentures, whatever might be the number or position of teeth added to the occlusion. Of the patients having 4,6,7, 5,6,7, or 6,7 added to the occlusion,* half had efficiencies less than 20 per cent at the end of a month. Among other groups, a majority of patients had less than 25 per cent efficiency. This indicated that when a partial denture occludes against an artificial dentition, neither the size of the partial denture nor position of teeth has much effect on the final chewing ability of the patient.

When the same type of analysis was applied to patients having partials occluding against the natural dentition (type N), the results were different. The midline of most groups ranged between 20 and 30 per cent rather than between 18 and 25 per cent. This seemed to suggest a general superiority for partial dentures occluding against a natural dentition. The comparison also suggested that a special advantage was possessed by small partial dentures replacing a missing first molar; these include partial dentures adding 6, 4,6, or 5,6, to the half dentition. Single first molar replacements had one-month efficiencies centering about 40 per cent, and replacements by 4,6 and 5,6 showed efficiencies centering about 50 per cent. This great efficiency could not be attributed to the type of support for the partial dentures; there were about equal numbers of tooth-borne and free-end saddles in this group, and the average efficiencies of each type were practically the same. The results indicated a special advantage to the small replacements in the first

*Four and five refer, respectively, to first and second premolars, and six and seven to the first and second molars.

molar region. For this reason patients with small partial dentures in the first molar region were treated separately from others with type N partial dentures, but were not separated when results on type A partial dentures were compiled.

The general findings are given in Fig. 1. Each group of columns represents a different period at which tests were run. For example, the first group of columns shows results of tests on patients during their first visit to the Prosthetic Department, before surgery or dental restorations have been made. The first vertical column is divided. The division on the left represents the average efficiency of small type N partial dentures in the first molar region. The right portion of this column indicates the average for all other type N partial dentures. The number of patients is shown by figures on columns. The right column shows the average efficiency for the group of 78 type A partial denture patients.

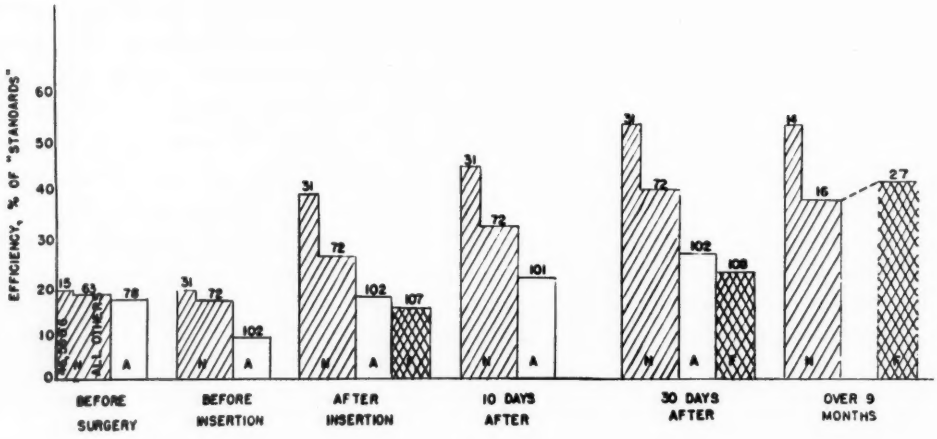

Fig. 1.

The average efficiency of patients selected for treatment ranged between 16 and 18 per cent before extractions. The base is a group of dental students in Boston who had two molars and two premolars in occlusion on the preferred side of the dentition. It appears that patients selected for partial dentures had lost on the average between 82 and 84 per cent of their average masticatory efficiency because of dental disease. The need for restoration seems to be obvious.

After surgery had been performed, the chewing abilities of the patients on the average were slightly but not significantly lower, because functioning teeth had been extracted in some instances. Immediately after the partial dentures were inserted, there were definite rises in the efficiencies of all groups. The greatest rise took place for the 31 type N patients receiving small replacements in the molar region. Somewhat less improvement occurred for other type N partial dentures, and the improvement was similar for type A partial dentures. The trend upward persisted through the ten-day to the one-month results. At one month, the average

efficiency of the small replacements in the first molar region was over 50 per cent. If was definitely different and better than the average for all other type N partial dentures; other type N partial dentures averaged less than 40 per cent. The partial dentures occluding against a full upper or lower denture did not show nearly as much improvement. Perhaps their improvement was limited by the instability of the full denture against which they occluded.

The efficiency achieved on the average by the partial denture occluding against an artificial dentition was surprisingly low at the end of one month. It amounted to only 25 per cent of normal efficiency and was about the same as the average efficiency of 100 full denture patients who were studied elsewhere.[9] It seemed important to determine whether or not denture patients of similar age at the Great Lakes Naval Training Center had equivalent efficiency. The average efficiency of full denture patients is shown by the height of the column marked F in the fifth group in Fig. 1. The average efficiency amounted to 21 per cent, which does not suggest that a partial denture occluding against a full denture has any particular advantage in efficiency over full upper and lower dentures.

It is possible that partial denture wearers do not usually reach their maximum efficiency by the end of one month. The question could not be answered with the same subjects, since recruits were being assigned to other parts of the country soon after one month at the Center. A suggestive answer was obtained by comparison with a separate group of patients. Fifty-seven persons who were in residence, rather than in training at the Center, were subjected to chewing efficiency tests. Thirty of these persons had worn partial dentures for nine months or longer, and 27 had full upper and lower dentures. The results are shown in the sixth group of columns.

Once again there appears to be a superiority for partial dentures in the first molar region, but there is no indication that efficiency continues to rise beyond the first month of use. The results with full denture patients differed. The average efficiency of the nine plus month group was nearly twice as great as for the one month group. The efficiency at nine plus months does not check with findings by Manly and Vinton.[9] If we accept 26 per cent as the average efficiency for full dentures, the type N partial denture wearer possesses a real advantage. If the average efficiency of the full denture is 41 per cent, however, there is doubt whether the partial denture wearer has any substantial advantage in ability to chew food. With type A partial dentures the conclusion is not in doubt. If masticatory efficiency were the criterion for judgment, one might as well provide the patient with full upper and lower dentures as to give him a partial denture which occludes against a full denture.

TOOTH-BORNE AND DISTAL EXTENSION PARTIAL DENTURES

The next question was whether or not tooth-borne partial dentures have any advantage in efficiency over free-end partial dentures. The patients were first divided into type N and type A partial dentures. Type N partial dentures were further subdivided into three groups. Small partial dentures in the first molar

region were first selected. Then a second group of small partial dentures were compiled, including those adding a second molar or one or two premolars to the dentition. Large partial dentures consisted of all other cases. The type A partial dentures were divided merely into two groups, since among these patients there appeared to be no special merit to small partial dentures in the first molar region; the groups were small partial dentures, having either 6, 7, 45, 5, or 4 added to the dentition, and large partial dentures, consisting of all others.

TABLE I. RELATIVE EFFICIENCIES OF FREE-END AND TOOTH-BORNE PARTIAL DENTURES

TYPE OF PARTIAL DENTURE	SMALL		FIRST MOLAR REGION		LARGE	
	BEFORE	1 MONTH AFTER	BEFORE	1 MONTH AFTER	BEFORE	1 MONTH AFTER
Occlusion with natural dentition						
Free-end	14(16)	28(16)	17(13)	50(13)	11(24)	40(24)
Tooth-supported	22(25)	41(25)	18(18)	54(18)	12(8)	31(8)
Occlusion with full denture						
Free-end	9(13)	29(13)	—	—	7(62)	24(62)
Tooth-supported	12(21)	25(21)	—	—	10(6)	20(6)

The results are presented in Table I. The figures represent the average efficiency of the group, and the numbers in parentheses indicate the number of patients averaged. There was little indication of a superiority for either type of partial denture. The greatest difference was in small type N partial dentures at the one-month period, when the tooth-supported restorations averaged 13 per cent higher in efficiency than did the free end. Tooth-supported partial dentures were initially 8 per cent higher in efficiency than free-end partial dentures. Hence, the free-end partial denture showed a 14 per cent rise in efficiency whereas the tooth-supported demonstrated a 19 per cent rise. These percentages are not statistically different.

For small type N partial dentures in the first molar region the beginning and one-month figures are nearly the same. For large partial dentures, a slight but insignificant advantage was shown by the free-end type. The rise in efficiency for type A partial dentures, and the average efficiencies at the end of one month were quite similar for both small and large partial dentures. There was no indication that a patient with one type of partial denture has any better chance for efficient mastication than a patient with the other type.

There are two beneficial effects which result from increase in average masticatory efficiency which patients experience, after they have become accustomed to partial dentures. These effects are shown diagramatically in Fig. 2. In this instance the groups of columns represent the average pulverization of the food at the time that the patient judges the food to be ready for swallowing. This is designated U_p to refer to a test with unrestricted number of chews, using peanuts as

a test food. It is the same value as the swallowing threshold of Yurkstas.[10] Once again type A and N partial dentures are plotted separately and the type N partial dentures are subdivided into small partial dentures in the first molar region and all others. The number of patients averaged for each group is indicated by the numbers at the top of the columns. The U_p averages parallel very closely the findings on the masticatory efficiency of these groups of patients. There is a steady trend upward from 49 per cent to 60 per cent for small type N partial dentures in the first molar region and from 25 to 42 per cent for the type A partial dentures. When a poor dentition is increased in efficiency, there is more influence on the pulverization of the food than when some minor deficiency is repaired. There is no indication of much improvement in the food pulverization at the swallowing time beyond the first month for cases with type N partial dentures. For full upper

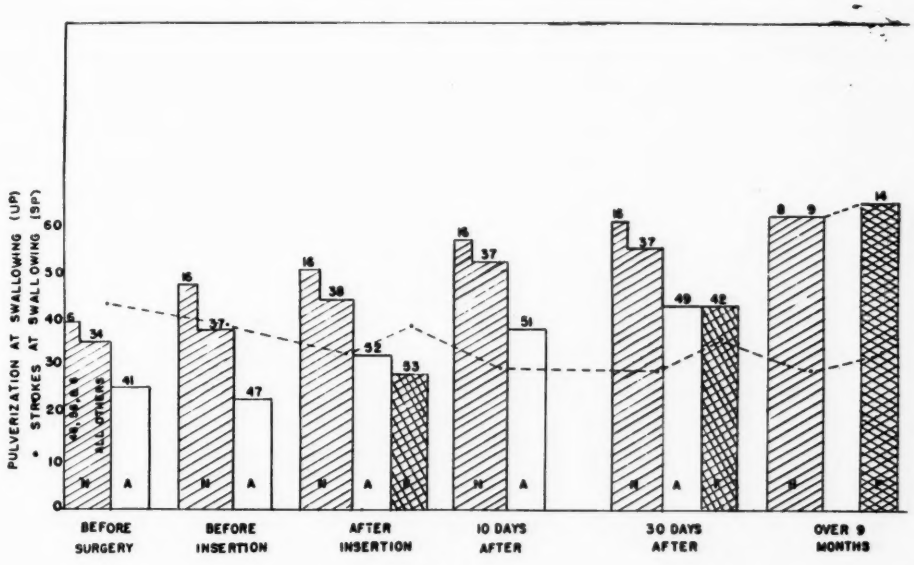

Fig. 2.

and lower denture wearers, the better trained group seems to be much superior to the group with one month of training, and the trained denture patients pulverize their food as well as do the partial denture patients. It can be concluded that the insertion of partial dentures has benefited the patient through causing him to masticate his food better than without the restoration. Since these tests were all made on the side preferred by the patient, they represent degree of pulverization that he would ordinarily make in preparing his food for swallowing.

NUMBER OF MASTICATORY STROKES

The number of strokes selected by the patients for pulverizing their food is an indication of the effort which they must use to prepare a standard test meal for swallowing. This is plotted as a dotted line in Fig. 2 as an average for all tests at each

period. Since the average numbers of strokes used by type A and type N patients were practically identical, all patients were included in the average for each period. Immediately after the partial dentures were inserted, the patients use fewer strokes than before. Apparently, patients recognize their better masticatory ability immediately, and unconsciously employ less effort (fewer chews) in mastication. There was no marked change from the first day to the first month. The full upper and lower denture patients who had one month's use of the dentures need 20 per cent more strokes in order to prepare their food for swallowing than do type A partial dentures. The complete denture patients select the same pulverization for swallowing as do type A partial denture patients, but because they average slightly less efficient, they must use more strokes. The groups trained for nine months need similar numbers of masticatory strokes for food preparation.

The small partial dentures in the first molar region were the only group to achieve efficiencies over 40 per cent. It seemed surprising to find that restorations generally did not restore the original efficiency in mastication, and this anomaly led us to question whether our standard of efficiency might be too high. The standard was based on 100 dental students in Boston whose half dentitions lacked one or more third molars. Such patients, with the half dentition having 4, 5, 6, 7 in occlusion, have been called "standard dentition patients." It seemed important to learn whether or not standard dentition patients among recruits entering Great Lakes Naval Training Center would have the same average efficiency. These data were collected and the results were averaged for 68 patients. The average efficiency of the Great Lakes standard dentition patients was found to be 90 per cent of the Boston patients. In order to calculate efficiency using Great Lakes patients as the base, one should divide the figures shown by nine. This still means that all except a select few of type N partial denture patients averaged 45 per cent or less in efficiency, and it does not change the conclusion materially.

DISCUSSION

A few of the findings have practical implications. Small type N partial dentures in the first molar region seem to provide the wearer with greater efficiency than either larger or smaller partial dentures. For example, a patient with mandibular teeth missing distal to the first bicuspid would be likely to benefit more from a replacement which added merely the second bicuspid and first molar than he would from a partial denture which added a second bicuspid and two molars. This result would be expected from our findings, whether or not the partial denture was free-end or tooth-supported. Probably this implication should be checked further before it is accepted without reservation. This could be done by a group which could try first one, then the other, type of partial denture on 30 cases having the proper numbers of missing teeth.

The mediocre performance of partial dentures occluding against an artificial dentition may also have meaning in treatment planning. When the patient already possesses a full upper or lower denture, one cannot justify the construction of a partial denture solely on the expectation of providing the patient with better chew-

ing efficiency. The justification has to be made on basis of comfort, convenience, patient preference, or some other reason.

In emphasizing the patient limitations of the type A partial denture and the large type N partial denture, the authors realize that these observations are based essentially on the one criterion, the short term ability to pulverize food. It is well recognized by the authors that many other factors should be considered in evaluating the over-all merit of different types of treatment. Such factors include the comfort and stability of the restoration, its tolerance by the supporting structures, and the ease with which the patient's oral hygiene can be maintained. Our hope is that other investigators will be encouraged to plan studies that will assess the importance of these factors in a quantitative manner.

SUMMARY

Masticatory function has been studied among 103 partial denture patients before and up to one month after completion of the prosthetic restorations. Their average masticatory efficiency and food pulverization were compared with the average for 42 full upper and lower denture patients one month after insertion, with 68 standard dentition patients, and with 27 partial and full denture patients who had had nine plus month's use of the restorations. Function measurements were made before surgery, before insertion, after insertion, ten days later, and thirty days later. At each period tests on masticatory performance were made for each half of the dentition, strokes required to prepare this food for swallowing were counted, and the degree of pulverization of the food was measured.

Patients selected for partial dentures had definite need of restorations, since their efficiencies averaged from 16 to 18 per cent of a standard dentition before surgery was performed. The average efficiencies for all groups rose immediately after the restoration was placed in the mouth, and more gradually thereafter, reaching the maximum efficiency in approximately one month. At this time the most efficient group was small partial dentures in the first molar region (adding 6, 46, or 56) which occluded against the natural dentition. Their efficiency was 63 per cent of standard dentitions tested at the same location. All other partial dentures occluding against a natural dentition average 39 per cent in efficiency at this time. Partial dentures occluding against an artificial dentition averaged 24 per cent in efficiency and were practically the same as full dentures one month after insertion. Tooth-borne partial dentures and free-end saddles had the same efficiency on the average.

The increase in efficiency caused by the partial dentures allowed the patients to obtain finer pulverization of food on the average before swallowing, with the more efficient groups showing better pulverization. The better preparation of the food was achieved with less effort by the patient as indicated by use of fewer masticatory strokes.

Acknowledgment—The authors wish to acknowledge the cooperation of Captain M. E. Simpson and Commander P. L. Brandt and the assistance of B. I. Sherman and David Brugler in work at the Great Lakes Naval Training Center. Help with statistical analysis was provided by Mrs. Joan Keyser and Miss M. E. Dreisbach at Tufts College Dental School.

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THE DYNAMICS OF INTERNAL PRECISION ATTACHMENTS

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ONE OF the purposes in the healing art is to preserve and maintain each bodily organ to its fullest extent. The function of the teeth and mouth is as important in the daily exercise of human endeavor as that of any other part of the body.

In the dynamics of partial prosthesis, with internal precision attachments, it is important to retain as many natural teeth as possible as a basis of partial restorations to prevent the disadvantage of an edentulous mouth and the problem of full dentures.

McCall and Hugel[1] have very aptly discussed the psychological aspect of the young or middle aged individual approaching the edentulous state. "To be or not to be edentulous is the question that arises in the minds of patients, when they suddenly realize they have only a few teeth left. The dread of the middle aged person of suddenly becoming old and the menacing fear of the younger people of having to go through life with a full denture becomes an emotional problem."

REQUISITES FOR IDEAL PARTIAL PROSTHESIS

Recognizing that comfort, efficiency, and esthetics are the prime motives involved in creating an ideal denture, two important factors must be considered: (1) the patient, (2) the denture.

The physical condition of the patient must be evaluated to determine the presence of any systemic disease which may contribute to rapid bone resorption under masticating stresses. Metabolic disturbances and certain endocrinopathies may influence the permanency of the denture function.

The tissues on which the saddles rest should not be hyperplastic. When present, surgical correction must be instituted. The underlying bone should be free of root apices, residual areas of infection, supernumerary and impacted teeth, cysts, and bony protuberances.

The remaining teeth should be considered as a group as well as individually. As a group, there must be a distribution of teeth on each side of the arch. When many teeth are missing, including all the molars, it is essential that both canines be present and serviceable. Individually, teeth to be used as abutments must be amenable to parallelism. They must be free from severe paradental involvement

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and have sufficient bony attachment. A short tooth with less bone attachment is often better than a long tooth with a greater amount of bone, from the standpoint of any leverage which may be exerted by a denture. Multirooted teeth need less bony attachment than single rooted teeth.

Elongated teeth should be reduced to the line of occlusion, even if root canal therapy has to be resorted to, to permit a harmonius relationship of both arches in lateral and protrusive movements. Slightly tipped and malposed teeth are not a deterrent to their use, if corrected or built up by full coverage and brought into alignment.

Fig. 1.—Cast with all teeth except the left central prepared for cast crowns with acrylic veneers.

Fig. 2.—Castings in position on the teeth with the female attachments in place.

The ideal partial denture should be so constructed that most of the stresses of mastication will be borne by the mucosa and underlying bone, and as little as possible by the abutment teeth. It must not impinge on muscle attachments or on the gingivae of the adjacent teeth. It should be perfectly adapted to the mucosa and move with it, instead of on it.

EVOLUTION OF PARTIAL PROSTHESIS

During the progress of prosthetic dentistry, there has been a gradual change in the construction of partial dentures from the use of soft tissue stress-

bearing principles to the use of certain teeth as abutments to share these stresses. Bent and cast clasps have been utilized, and when indicated have served their purpose well.

The introduction of male and female attachments as part of the technique of internal precision prosthesis has become another milestone in the evolution of prosthetic progress.

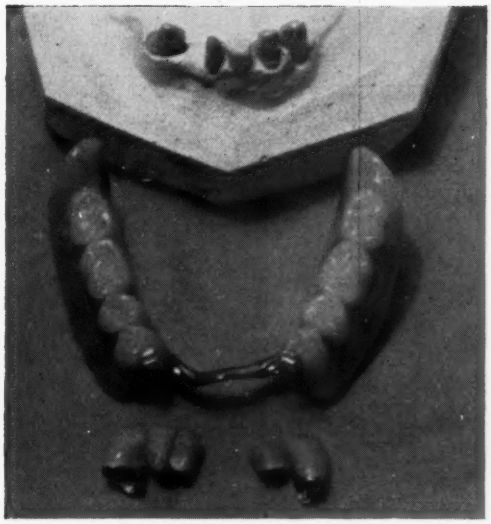

Fig. 3.—The right lateral incisor is replaced as part of a fixed bridge and left lateral and canine are splinted. The male attachments are in position on the finished restoration.

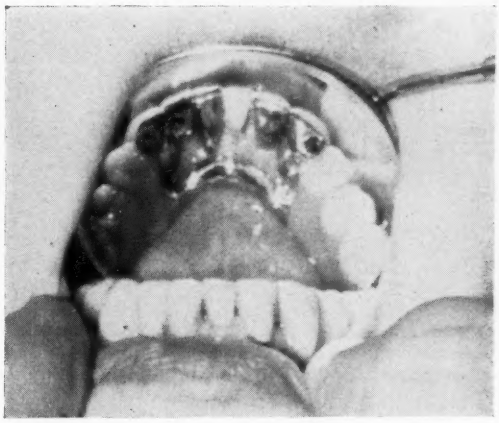

Fig. 4.—The completed restorations in position in the mouth. This patient had become emotionally disturbed because of having worn a cast clasp denture which had functioned badly and had been unsightly. The resulting stabilization with restoration and precision attachments and the change in her appearance resulted in a mood consistent with decreased emotional disturbance.

INDICATIONS FOR CLASP DENTURES AND PRECISION ATTACHMENTS

The question arises when to use direct clasp retention and when to use the internal precision attachments.

Direct clasp retention in the construction of a removable restoration is indicated: (1) when the general hygiene promises to be good; (2) when the remaining teeth have no periodontal involvement and are properly distributed for clasping; (3) when the abutment teeth have the necessary convexity and lend themselves to proper clasping; (4) when the denture can be expected to render many years of service.

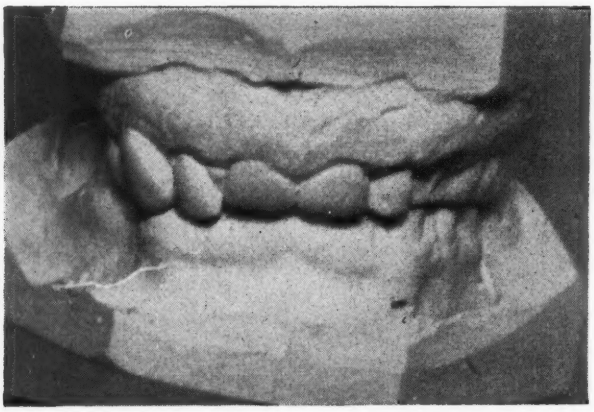

Fig. 5.—The mandibular anterior teeth were concealed, and the mandible was displaced by the maxillary teeth with an abnormally closed occlusion.

Fig. 6.—The mandibular molar was in contact with the maxillary occlusal ridge.

Internal precision attachments are indicated: (1) when few remaining teeth are present; (2) when the hygiene promises to be poor; (3) when the abutment teeth are overfilled or broken down, yet are serviceable if they are restored by full coverage; (4) when splinting of teeth is indicated to aid in their preservation; (5) when the economic status of the patient is such as to permit their use.

There are certain situations in which the distribution of teeth is such that clasps cannot be used efficiently. Among these are: (1) Those in which only six anterior teeth are present. Canines are poor teeth for clasping. The visibility of clasps presents poor esthetics. The caries susceptibility and poor retention form are contraindications for the use of clasps. See Figs. 1 to 4. (2) Unilateral cases. These present difficulty in attaining perfect balance. See Figs. 5 to 9.

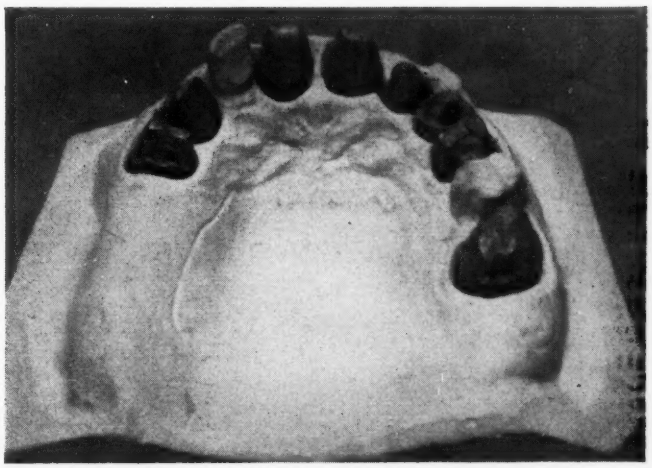

Fig. 7.—All maxillary teeth, except the right lateral incisor and the left second premolar, were prepared for full cast crowns with acrylic veneers.

Fig. 8.—The completed restorations with male attachments on the truss arms.

(3) Those with only two canines present. The internal precision attachment restoration is the only type of restoration which can be expected to function successfully. It would be poor judgment to construct a clasp denture for a mouth with few and improperly distributed teeth which may only delay the construction of a full denture. See Figs. 11 and 13.

The internal precision attachment will improve the esthetics, eliminate trauma, and prevent caries, displacement, tipping, or rotation of the abutment teeth and settling of the partial denture. The attachments, being parallel, help to maintain a splintlike effect on the abutment teeth. Speech difficulties are avoided because of elimination of large bars and retainers. They permit more normal heat, cold, and taste perception. This type of appliance is the nearest to fixed bridgework in efficiency.

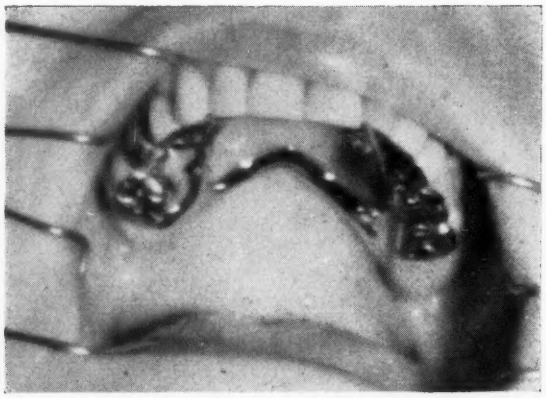

Fig. 9.—The completed restoration in the mouth. The unilateral case is very often sufficiently difficult to restore efficiently. Precision attachments may be one means of solving such a problem. When complicated with a closed occlusion, such a restoration may be the means of creating both masticatory efficiency and excellent esthetics.

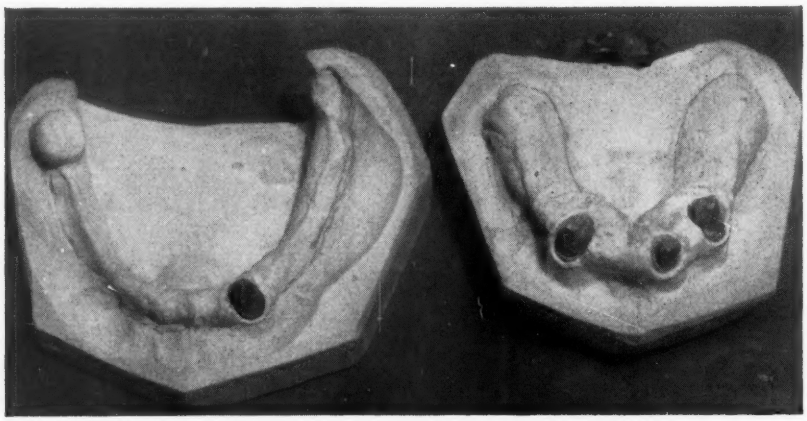

Fig. 10.—Casts and preparations for full crown coverage of the remaining maxillary and mandibular teeth except the right molar.

MECHANICS

I practically limit my internal precision attachment work to those cases in which the abutment teeth are broken down. They must be fully covered. When perfectly good teeth are present, a clasp-retained denture is justifiable to avoid

cutting into them for castings when the denture can be expected to function successfully.

The necessity for thorough detail is important in securing success. The abutment tooth must be prepared with a recess so that the female attachment can be incorporated within the contour of the cast crown. The male attachment must be incorporated into the framework of the bar to give it strength, and to facilitate its insertion into the female attachment. This, of course, necessitates parallelism of the female attachments.

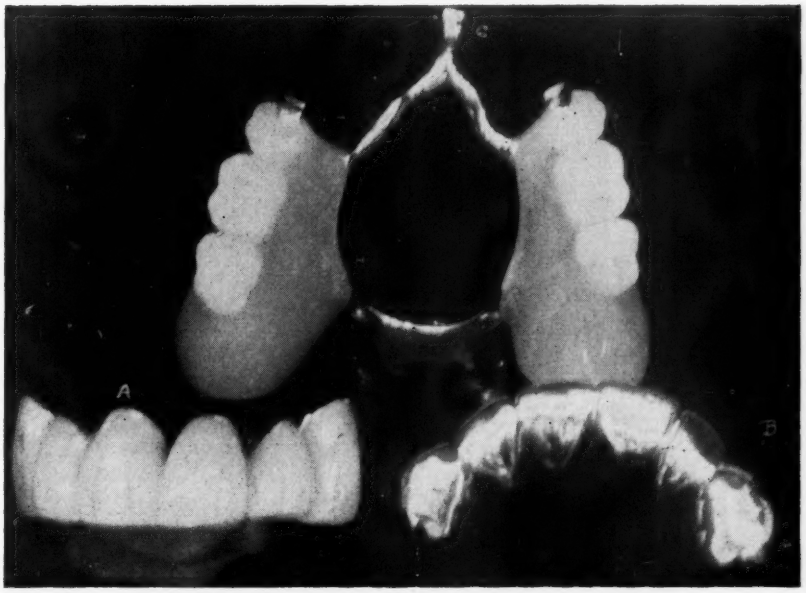

Fig. 11.—*A*, The temporary acrylic bridge which was worn during the construction of the dentures. *B*, The fixed bridge with female attachments placed in both cuspids and left central incisor pontic. *C*, The completed removable restoration.

It is important to relate the male attachment to the saddle in such a manner as to prevent complete seating in the female jacket. This is accomplished by making certain that about ½ m.m. of space is permitted between the gingival end of the female attachment and male attachment, so that vertical occlusal stress will permit the saddles to displace the mucosa and receive support from the bony structures, thus eliminating trauma on abutment teeth.

The question has often been raised as to whether full tooth coverage may necessitate the cutting down of a good tooth. In most mouths where many teeth are missing, the remaining teeth are often overfilled and broken down and require full coverage. If an occasional abutment tooth is in good condition, there should be no objection to preparing it for a MOD inlay or three-quarter crown into which an attachment can be placed.

When patients present only two canines in either arch and they have good healthy alveolar bone with no periodontal or gingival involvment, the use of a fixed anterior bridge with full crown coverage and an internal attachment on one of the central pontics, as well as on the distal of the canine crowns, provides good retention. If the saddles are carried over the maxillary tuberosities or the mandibular retromolar pads for good seating, and the male attachments are so related to the saddles as to permit the displacement of the mucosa, and transmission of the masticatory stresses to the bone which underlies it, there need be no fear that the denture will not function successfully.

Fig. 12.—The upper restorations in place in the mouth.

Fig. 13.—Both restorations in occlusion in the mouth. This patient representeed an individual who felt that the presence of only a few of his own teeth would make a very marked difference in his outlook on life. The stability created by internal precision attachments offered a means of lessened emotional instability.

The unilateral edentulous jaw has always been a problem. With full tooth coverage and a well constructed saddle for the edentulous area, precision attachments offer far better efficiency than crib clasps.

CONCLUSIONS

It is evident that the internal precision attachment as a means of retaining partial prosthesis has its place in dentistry.

In many instances where few teeth remain, it is the only method of retaining a partial restoration and avoids the necessity for resorting to full dentures.

When indicated, the internal precision attachment offers a method of denture construction conducive to emotional stability, excellent esthetics, and good masticatory function.

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AUXILIARIES IN OPERATIVE DENTISTRY

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1. LIGHT IN DENTISTRY

OPERATIVE dentistry concerns itself with dimensions accurate to one-thousandth of an inch or less. To obtain sharp definition in close dimensions, proper lighting becomes a critical problem. The human eye is like a camera lens. Photographers know that to obtain a good depth of focus with a camera lens, one must use bright light and a small lens opening. This is a rule of optics and is true regardless of how accurately the formula of the lens grinding for spherical and chromatic aberration has been computed. The same rule applies to vision. Although the iris of the eye and physiologic changes in the retina (visual purple) make compensation for poor lighting, and although the lens makes correction for distance, if the subject viewed is small and up close, the depth of focus is shallow and vision will be indistinct in poor light. Visual acuity and good operative dentistry demand abundant light.

Dentists who hold offices where A.C. electric current is available should take advantage of fluorescent lighting for general illumination. The source of light for spot illumination should be from a high-heat incandescent tungsten filament, but general illumination is better furnished by fluorescent lighting.

The spot light should provide about 1,000 foot candles of illumination at the operating distance. Lighting engineers say that to prevent eye fatigue from too great a range of adaptation general illumination should be no less than one-tenth of the intensity of the spot light. This would mean that the general illumination of the operating room should provide 100 foot candles of light at operating level.

A room properly illuminated for dental purposes may seem unusually brilliant to a dentist unfamiliar with scientific lighting. In considering the light values of a dental office, the light engineer will take readings with a light or exposure meter turned toward the light source at operating level. The reader should not confuse this method of taking light readings with the method he employs in photography. In photography the exposure meter measures the *reflected* light energy. A thousand foot candles of light as recorded by a Weston Meter (actually 1,000 footlamberts) is approximately the amount of light reflected from a light subject in bright sunshine. One hundred foot candles is about the amount reflected from an average subject in the deep shade of a large tree on a bright day. Obviously

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regardless of how brightly the operating room is lighted, the reflected light will always be of a much lower order than exists in sunlight. The statement is sometimes made in connection with indoor lighting problems for close work that it is almost impossible to get too much light.

Spot lighting for dental needs has received much of the dental manufacturer's attention. The dentist will do best to select his spot light from the suppliers of dental specialties. He should, however, select a tungsten type light because the light is concentrated and the lag in cooling of the hot filament irons out the flicker due to cycle changes of the power line.

For general illumination diffusion rather than concentration is needed, and the diffuse glow of the fluorescent light bulb is precisely the feature which recommends fluorescent lighting. It is well to remember that the patient is facing the light employed for general illumination. Fluorescent lighting is easy on the eyes and this recommends its use in portrait photography. It is more efficient than hot filament lighting, therefore, much more light will be obtained per watt of electricity consumed. Through their efficiency fluorescent fixtures stay cool when in operation and this is an advantage in hot and humid weather.

Fluorescent lighting depends upon an electronic discharge or flash between two electrodes of a partial-vacuum tube which takes place during the alternation of current flow. Since the cycle of ordinary A.C. current in most parts of the U.S. is repeated 60 times a second, the flash of a mercury vapor or a gas filled, partial-vacuum tube is of very short duration, occurring 120 times a second. There is darkness or absence of light between flashes, and this interruption of light gives rise to the so-called stroboscopic effect. Under sufficiently reduced gas or mercury-vapor pressure, arc discharges of this nature give rise to ultraviolet light of very short wave length.

The stroboscopic effect, while valuable for certain purposes, is objectionable ior lighting purposes. For practical general lighting, it is necessary to have a constant source of illumination. Lighting engineers achieved this effect by coating the inside of the fluorescent light tube with a powder which glows under the influence of ultra violet light, and this glow or fluorescence persists for a long enough time between the intervals of the discharges to produce the effect of glowing continuously. Very efficient fluorescent powders and the use of ballasts in the circuit of multiple-tube fixtures whereby half the tubes are discharging when the other half are on the recessive cycle make present day fluorescent lighting completely free of stroboscopic effect.

Fig. 1 shows how I have illuminated my office. The fluorescent fixtures are hung seven and a half feet from the floor and on each side of the chair to reduce shadows. Eighty foot candles of general illumination can be obtained at operating level in the entire operating space from the eight 40 watt tubes of the combined fixtures.

White light (not daylight) is recommended, and the best light at the present time is that furnished by the new deluxe *cool white* fluorescent tubes. The latter give a light richer in the red end of the light spectrum. Flesh tones appear warmer in this light.

The room size has importance in determining the number of tubes to obtain proper light balance as does also the color of the paints on the walls. Light walls and ceiling reflect more light and fewer tubes need be used for a given light effect. The room shown in Fig. 1 is 8 feet by 10 feet, the ceiling is white, the walls a light blue-green.

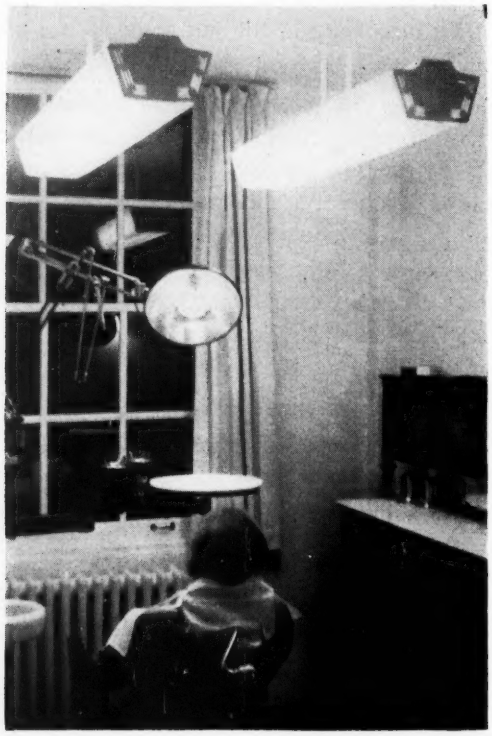

Fig. 1—Operating room illumination. Each fixture holds four 40-watt fluorescent tubes.

2. AIDS TO OPERATIVE DENTISTRY

Much of inlay operative dentistry and even more of crown and bridge dentistry makes use of large rotary tools such as carborundum stones and disks, diamond abrasive forms, and sandpaper disks. With the growing realization that prosthetic abutments should be rather large, complex, but thin castings, well-braced externally, dentists have turned to diamond abrasive rotary tools for fast and safe surface reduction of tooth structure.

Dental literature bears many references to the use of the rubber dam for inlay cavity preparation, and perhaps incipient caries can be most ideally managed in this manner. Nevertheless, it is common knowledge that patients dislike the rubber dam, and surgery upon teeth with incipient caries is by no means the usual type of operative problem which comes into the average office. There appears to

be no emphatic reason, personal preference aside, for maintaining dryness during inlay cavity preparation; and since carborundum stones and diamond abrasives are rather large for the space provided and furthermore work better when moist than dry, the dam is a hindrance.

When dryness is essential (as in placing a cement base) the instruments shown in Fig. 2 serve the purpose very well. They are offset to the right and left. When the handle is grasped by the patient, the offset permits free access to the cavity in question. Fig. 3 shows the method of use. Cotton rolls are placed in the

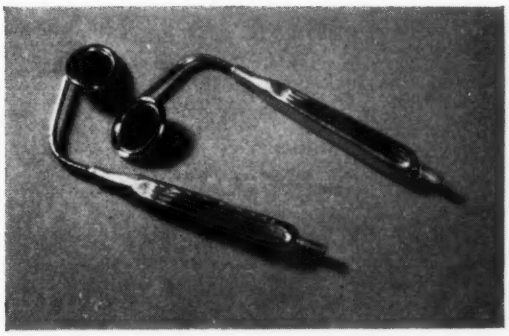

Fig. 2—Combined tongue deflector and saliva ejector.

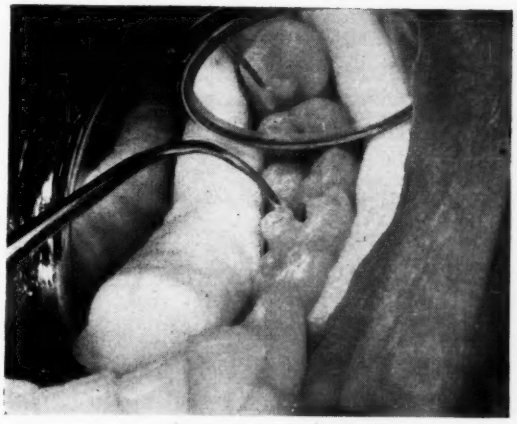

Fig. 3—Use of saliva ejector with tongue deflector for cementations.

upper and lower buccal vestibules and a third cotton roll is placed between the tongue deflector and lingual surfaces of the teeth. The instrument is connected to the saliva ejector tube and serves to evacuate saliva in addition to deflecting the tongue. Oftentimes the muscles of the floor of the mouth are attached to the internal oblique ridge very closely to the necks of the lower teeth. If the tongue is thick and very muscular, it almost fills the mouth with the jaws well separated. With the assistance of the patient even these difficult cases can be maintained in dryness for as long a duration as needed.

While the instruments are generally intended for use when the operation is in the lower jaw, the illustration cited above often presents a problem for upper cementations as well, both with respect to placing a base as well as for the setting of inlays or bridges. When the instrument is in use, if the cotton rolls show signs of saturation, it is a simple maneuver to remove the wet cotton roll and replace it with a dry one while momentarily holding the cheek or tongue deflected.

Little imagination is required to see that these instruments have other uses as well. As a tongue guard for cavity preparation and filling operations for childrens' dentistry it is very serviceable. It does little good to exhort youngsters to keep their tongue away during operative measures. If the blade is placed in the mouth, exploration on the young patient's part is immediately stopped. If the child cannot be depended on to hold the instrument down, it is better to just let the instrument rest by its own weight in the lingual vestibule. Sometimes the dentist can hold the instrument down with a free finger or the dental assistant can be called to serve. Usually, however, most operations can be done without the need of her presence. The tongue deflectors here described come in two sizes of blades. The smaller is intended for children although I have used only the large size throughout the years of my practice for adults and children alike.

While it is desirable to have one's assistant close at hand, she has many duties in a busy office; and when work can be simplified, her presence elsewhere often makes for a more smoothly running office. In the use of the combined tongue deflector and saliva ejector, when the patient is enlisted for assistance, the dentist positions it to allow the greatest amount of free space possible and asks the patient to grasp the handle and hold it just so. I have become so thoroughly dependent upon these instruments for cavity preparations that I would be lost without them. I have four sets on hand so that one set is always available in each room while the others are in the process of sterilization.

With the instrument in place, protection for the tongue, mucosa, and muscles of the floor of the mouth, as well as operating room, are provided when disks or large abrasives are employed. The cheek is deflected with a mirror or free finger of the left hand while the handpiece is held in the right. If grinding is done under a spray or water-jet, water, saliva, and debris will be aspirated at the same time that the tissues are deflected. The tongue blade so used is primarily intended for lower operative purposes but, again, there are many situations where it may be used to advantage for upper posterior preparations.

3. DIAMOND ABRASIVES

The two most significant developments of the past ten years in operative dentistry are the general adoption by the Profession of industrial diamond as abrasives and hydrocolloids as impression media. The latter subject has been rather adequately covered by essayists particularly as it relates to technique. The educational program behind the use of diamond abrasive forms, however, has been largely left to the commercial houses interested in fostering sales. This article will endeavor to outline the advantages to their use, describe the methods of use, and furnish sup-

plementary data of value to the practicing dentist. The subject matter is intended primarily for inlay and bridge restorative dentistry.

Industrial diamond or gem-diamond particles are used to impregnate various forms considered by diamond abrasive manufacturers to suit the various dental needs. Industrially diamond may be used as a single crystal mounted on a dressing tool, as a dust pressed into the edge of a high speed disk, as a slurry, or a particle mounted in a permanent binder to a tool. For dental purposes diamond particles of appropriate size are mounted on grinding forms as in the last named instance.

Diamond tools are distinct from burs or cutting tools in that they work by a scoring action, that is, each diamond particle scrapes off the surface of the object it is abrading to the depth of the diamond protruding from the tool. Since the size of the diamond particles is of a very low order and since the diamond particle will only cut to the depth it penetrates, diamond abrasives should be used at high speed and with light pressure. Light pressure minimizes frictional heat. Experimental research was carried out in Germany at the time diamond tools were first introduced to the dental profession to determine whether diamond tools are best used wet or dry, and the conclusion was that they work best in a moist loose slurry of the abraded material—both too much water and dryness should be avoided.

Burs are cutting tools and work by the action of revolving blades. Today the best bur steel is about 64 on the Rockwell "C" scale or about 791 Knoop. Dental enamel is about 267 on the Knoop scale. While the differential in hardness of the two media is not too close, it must be kept in mind that when grinding

TABLE I.

COMPARISON BY INDENTATION TESTS			COMPARISON BY ABRASION TESTS	
		MOHS SCALE NATIONAL BUREAU OF STANDARDS WITH KNOOP INDENTER	BASED ON LAPPING TESTS BY C. E. WOODDELL AT CARBORUNDUM CO. LABORATORIES	
Talc	1			
Gypsum	2	32		
Crystalline quartz	7	710–790		7
Topaz	8	1,250		
Tungsten carbide		1,050–1,500		
Corundum (sapphire)	9	1,700–2,200		9
			Tungsten carbide (12% cobalt)	12
Silicon carbide		2,050–2,140		
Diamond	10	8,200–8,500		42

through enamel, the small sized burs heat up rapidly, lose temper, become dull, and thereafter generate much heat. A bur tends to be selective in its cutting. It will cut the softer substances like dentin or cement much more readily than enamel. When pressed against a composite of cement, dentin, and enamel, as in drafting a cavity wall after placing the cement base, it will tend to vibrate against the enamel and chip the cement.

Diamond, on the other hand, is the hardest substance known to man. Table I shows the relative hardness to indentation and abrasion tests of substances familiar to the average dentist.

Diamond tools are not selective in their grinding action. They will grind enamel, dentin, and cement at an equal rate, and are therefore perfect finishing tools for producing draft in inlay cavity preparation. Furthermore, unlike burs, they grind with equal efficiency in a counterclockwise or clockwise direction. They should always be turned in the direction to avoid chattering. In approaching a sharp edge, the tool should be turned away from the edge rather than toward it.

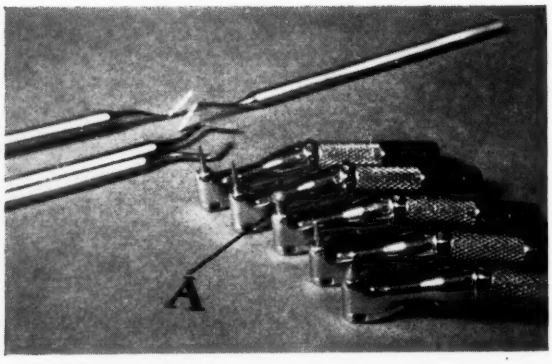

Fig. 4—Diamond "finishing" tools for inlays.

Carborundum stones and mounted points have many of the advantages of the diamond abrasive forms but they have one disadvantage—they wear down in use. In positions of difficult access, it is difficult to control the exact shaping of the cavity with carborundum points because the stone itself abrades rapidly and breaks off. To be effective grinding tools, carborundum tools must be formed of a binder soft enough to break down readily on the surface being ground to constantly present new sharp layers of carborundum to the grinding action. If the stone is made too hard it will not cut well and will generate much heat in use. The binder does not always break down uniformly in use and this gives rise to eccentricity in rotating carborundum tools which further limits their desirability.

Fig. 4 illustrates the assortment of diamond tools I find useful for cavity preparation of individual restorations. Fig. 5 illustrates a useful assortment for bridge abutment preparation. Since teeth which support prosthetic appliances usually require much surface reduction, rather large disks and wheels should be used for the reason that the greater the circumference which a given diamond particle travels

the faster it moves and the more ideally it fits the previously stated rule. When such tools are used moist and with discretion, large surface reductions can be achieved easily, quickly, and safely.

USE OF DIAMOND TOOLS

With good shadow-free light and the field of operation open to view, we are now in a position to make the most of our abrasives.

No attempt will be made to present an exhaustive exposition of uses for diamond abrasive forms, nor will the step-by-step procedure of cavity preparation be considered at this time. The reader is referred to text books for this treatment of the subject. A resume of my experience with diamond forms, however, may have interest.

To be of value as finishing tools the diamond forms have to turn in a vertical axis in the intermaxillary space provided for any given case. Frequently the intermaxillary space is very close. It will be to the dentist's advantage to have rotary finishing tools such as shown in Fig. 4 prepared with short neck or short shank

Fig. 5—Diamond tools for crown and bridge preparation.

lengths. The length of shank of the ordinary contra-angle bur is too long in the molar regions of many mouths to permit using the tool without displacing the contra-angle to the buccal or lingual. This seriously affects proper or critical drafting of cavity walls. If a sufficient number of straight-handpiece, diamond forms are purchased at one time, most reputable diamond tool manufacturers will be willing to cut the shank to the desired length specified by the dentist. I would recommend the short neck and short shank lengths for pieces such as shown in Fig. 4. The short length rotary tools also place less thrust on the bearings of the contraangle.

The tapered diamond forms *A* of Fig. 5 should have a pointed end and not a stub end for the reason that if the handpiece is moved from the vertical axis a little in drafting the proximal box of a given preparation (as must be done to avoid nicking the approximal surface of the adjacent tooth), the operator will inadvertently cut grooves or undercuts into the box with the stub end of the tool. A diamond tool which ends in a point will never present this problem.

The convex disk works well for surface reduction of large preparations such as the jacket crown. It may be used on the buccal, lingual and distal tooth surfaces. The mesial surface is best prepared with a safe-sided straight disk. Often in the preparation of molar teeth the incisal edges of the lower anterior teeth are high with respect to the occlusal table of the lower posterior teeth and it is difficult to carry even a 7/8 inch disk gingivally far enough to reach the gingivae. This is most frequently realized when using a straight disk to draft the mesial surface of a molar abutment. When the disk is held in a contra-angle attachment, the difficulty may sometimes be surmounted but more frequently the head of the contra-angle will engage the anterior teeth, and the above relation will again present itself with the further disadvantage that the disk will not run as true. A useful recourse in these cases is to use the extra long mandrel shown in Fig. 5. While the extra length of

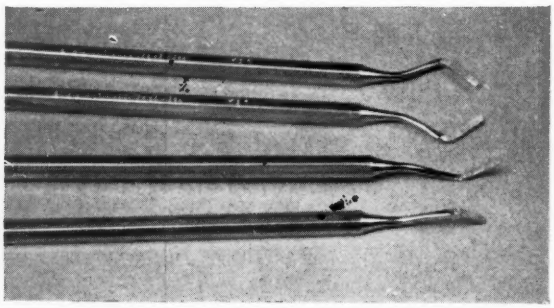

Fig. 6—Diamond hand instruments for beveling the gingival margin.

mandrel makes handling of the disk a little more awkward for finger rest positions, the additional vertical working space is compensation well worth the effort.

The diamond tool marked *A* of Fig. 4 is extremely desirable. When supplied with a short shank it can be used to prepare the buccal and lingual surfaces of almost any posterior tooth without forcing the contra-angle attachment too far down the patient's throat or requiring so much displacement of tissues as to cause discomfort or nausea. The instrument is best used for the difficult job of rounding off corners after the axial reduction of buccal, lingual, mesial and distal for jacket preparation. It also works well to extend cavity preparations beneath the free gingivae onto sound tooth structure on buccal and lingual surfaces. Dentists frequently have to make jacket preparations over teeth that have had large buccal amalgam restorations with recurrent caries along gingival margins. When the amalgam is removed, excavation carried out, and the cavity based, the extension of the abutment preparation over the cement base is difficult even with gum resection or retraction, because of the laceration and bleeding incident thereto. In my experience the above method followed by sandpaper disking serves the purpose best.

The only other procedure in cavity preparation employing diamond tools which I shall discuss is the use of the instruments shown in Fig. 6. Since the above are hand instruments, their use would seem to contradict the preceding dissertation because the movement of the diamond particles against a cavity surface

is very slow indeed. These instruments are intended only for the specialized job of preparing the gingival margin.

Very often the gingival margin of the proximal box will be very close to the approximal surface of the adjacent tooth. This will most frequently occur in cavity preparation for young people. To pass a safe-sided lightning disk between the teeth is objectionable because of the multilation of the periodontal tissues and excessive display of gold in the resulting inlay. If the box is shallow, it is often difficult to pass even a Woodbury margin trimmer between the teeth. It is inadvisable to turn a diamond point along the gingival margin to produce a bevel because of the danger of scuffing the approximal surface of the adjacent tooth. One of the four hand instruments shown, however, can usually be used very effectively to produce a nice bevelled continuity from the flared box to the gingival floors. The instruments can be used with a push-pull as well as a side-to-side movement. The files and gingival margin trimmers can only be used in one direction. Since the above diamond files are very thin, they can be used to bevel the gingival floors of cavities in extremely close quarters. The bevelling of the gingival floor is rather easily achieved because the enamel rods along the edge of the gingival floor are unsupported by dentin. The rough surface left by the diamond instrument can be smoothed off by subsequently rotating a medium cuttle disk against the bevel and carrying the disk while rotating onto the flared buccal and lingual axial surfaces of the box to complete the bevelled transition.

A MODIFIED THREE-QUARTER VENEER CROWN

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IN THE past, gold in the anterior portion of the mouth may have been a desirable sight, but in our changing culture we now keep gold as far posteriorly as possible. However, as long as anterior teeth are lost in accidents and to our old enemy decay, gold must necessarily be used to aid in the replacement of these anterior teeth. We have progressed from gold crowns on the anterior teeth to porcelain crowns and finally crowns made of acrylic. By combining gold and acrylic in the same restoration or retainer, we combine the strength of gold with the beauty of acrylic. Thus in the progress of dentistry I wish to suggest nothing new, but a combination of the old tried and true preparations together with the old and new in materials.

PREPARATION

The preparation for this restoration is carried on in the beginning about the same as for a normal three-quarter crown preparation, with a few exceptions. The length of the tooth is first reduced by removing approximately 2 mm. from the incisal edge. Next remove the proximal undercuts with a safesided ¾ in. diamond disc. Remove any labiolingual undercuts formed by the labiolingual curvature of the tooth down to the free margin of the gum. Connect the proximal cuts with the labiolingual portions of the tooth at the gingival level to form a continuous circumference at the gingivae (Fig. 1). At this point, a seamless Crandall copper band is fitted to conform tightly to the cervical outline of the undercut-free tooth. This is done with crown and bridge shears. Be sure to smooth all cut edges of the band, inside and out, with a rat tail file so the band will not damage the gingival tissue after the completion of the preparation. Next remove enough lingual enamel to allow approximately 0.5 to 1.0 mm. of clearance of the occlusion, both in centric and protrusive positions of the jaw.

Approximal grooves are placed midway between the labial and lingual surfaces. A tapered diamond stone is used with a continuous stream of warm water to remove all labial enamel to form a sharp 90 degree shoulder at the level of the free margin of the gingivae. This shoulder extends across the labial surface of the tooth. The lingual extent of this shoulder is formed by the lingual side of the grooves that have been cut previously on the approximal surfaces of the tooth. After the shoulder has been established at the level of the gum line, it is carried

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up under the free margin of the gingivae (approximately 2 mm. wherever possible, as the individual relations allow). On any upper left tooth this is done by rotating a tapered diamond stone clockwise as you cut down the mesial slope, and counter clockwise as you cut down the distal slope. The rotation is in the opposite direction for any upper right tooth.

The finish line on the proximal and lingual surfaces is carried under the free margin of the gum with a pointed diamond stone and is connected at the labial proximal surface to the cervical extent of the labial shoulder. In examining the completed preparation, there must be at least one and a half millimeter to two millimeters of clearance between the incisal edges of the opposing teeth when the jaw is in protrusion. Also, no undercuts must exist in the preparation at any point.

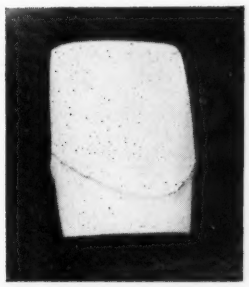

Fig. 1.—Undercuts have been removed from all surfaces to 10 mm. below the free gingivae.

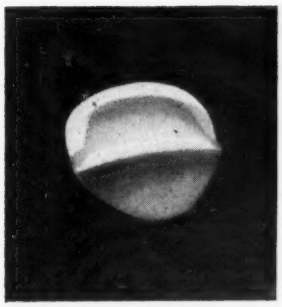

Fig. 2.—The completed preparation. The labial shoulder is continuous with lingual finish line.

The shoulder under the free margin of the gum can be made sharp by using a 702 tapered fissure bur, being careful not to cut the gingival tissue, or to use lateral pressures which would form a cervical undercut (Fig. 2).

IMPRESSIONS FOR DIES AND CAST

The seamless copper band, which was fitted before the shoulder has been established, is now filled full of red stick compound and placed on the end of a tapered fulcrum stick. The fulcrum stick permits the excess compound to come out the incisal end of the band instead of forcing its way out at the gingival end of the

band as the band is forced down over the preparation when the impression is made. This will prevent distortion of the impression after the compound-filled band has been completely seated (one-half millimeter past the preparation); it is chilled with cold water and removed with a snap. This impression is laid aside.

A crown and bridge tray is filled with softened Aluwax and forced over the anterior teeth so as to make an accurate impression of the preparation as well as of the adjacent teeth. The Aluwax is removed from the mouth after having run cold water over it. The Aluwax impression is chilled thoroughly in cold water, then by means of a pointed instrument such as a Woodson No. 1, a slight bit of excess Aluwax is taken up from the edge of the impression, warmed just to the flowing stage, and put in the area where the shoulder of the preparation would show in the impression. The chilled Aluwax impression, with the warm wax added in the shoulder area, is reinserted in the mouth and forced into position. This procedure is repeated until an accurate impression of the preparation is secured. This impression is now laid aside until the amalgam die or copper-plated die can be constructed from the compound impression of the individual tooth preparation in the seamless copper band.

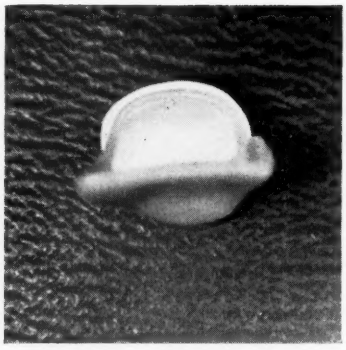

Fig. 3.—The midproximal waxing prevents gold from showing labially after the labial acrylic is added.

After the die has been completed, assemble it into the chilled Aluwax impression, making certain the shoulder of the die is seated tightly against the impression of the shoulder in the Aluwax impression. Seal the die into position with a small amount of the excess Aluwax taken from the edge of the impression. Lubricate the die and pour up the impression in stone. In finishing down the amalgam die or copper-plated die, taper the root portion so that it may be removed from the finished cast to facilitate the waxing of the restoration.

WAXING

Lubricate the die and apply one thickness of 30 gauge pink matrix wax over the entire preparation, trimming wax exactly to the finish line. Flow sufficient hard inlay wax over the lingual and proximal surfaces of the die to form the original contour and contact areas of the tooth being restored. Also build up the incisal

portion of the pattern so it is continuous with the lingual surface, as in the waxing of a three-quarter crown. The labial portion of the pink matrix wax is removed, except about one millimeter of pink wax is allowed to lap over the labio-incisal portion of the preparation. The inlay wax on the proximal surfaces is carved so that no wax extends past the midproximal line of the adjacent teeth (Fig. 3). The lingual portion of this restoration is retained by being waxed around the lingual portion of the labial shoulder, thus forming a labiolingual lock. After the lingual portion has been waxed, a round bar of 20 gauge wax is laid on the labial surface of the preparation, 2 mm. above the shoulder. This bar is sealed to the

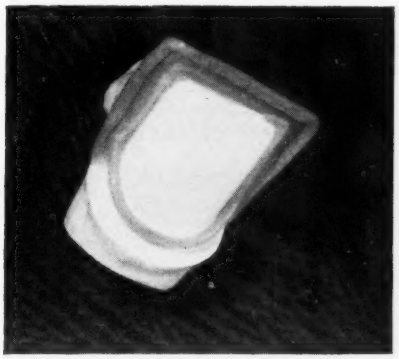

Fig. 4.—The waxed lingual portion. The incisal edge, the labial retentive loop and the retentive undercuts are carved in.

Fig. 5.—The waxed crown removed ready for casting.

lingual waxed-up portion of the pattern. The final step in waxing is to undercut the approximal portions of the waxed crown with a Woodbery or Crandall instrument or any suitable instrument (Figs. 4 and 5). The waxed crown is sprued at the lingual incisal angle as in a normal three-quarter crown. The finishing of the gold casting preparatory to waxing the labial surface is accomplished by using wheel burs to reundercut the proximal and incisal portions of the casting. The labial retentive loop is relieved from the tooth side, and then thinned and flattened until it is very thin.

WAXING OF LABIAL SURFACE

Pure tin foil 0.0005 in thickness is adapted over the entire labial surface of the crown portion and extended one millimeter onto the root portion of the die. After the tin foil is adapted, the finished casting is placed on the die over the foil. White inlay wax is flowed over the labial portion of the crown, shaped and carved with appropriate anatomy. The wax is extended cervically 1 mm. past the finish shoulder to cover the 1 mm. of excess tin foil. This is done to allow for finishing after processing. The crown is packed and processed the same as an acrylic jacket. If the tooth is relatively flat on the labial surface, the gold may be masked by opaque acrylic or other masking materials. After the processing is complete, deflask and trim the cervical excess by placing the crown on the die and trimming the excess down to the shoulder of die with a 557 bur revolving at high speed.

SUMMARY

The preparation of a modified three-quarter veneer crown is a combination of a three-quarter crown and jacket crown preparation procedure. The preparation incorporates the retentive features of the three-quarter crown with its saving in tooth structure and the esthetics of the full jacket crown.

The modified three-quarter veneer crown is used whenever a jacket crown is needed as a retainer for a bridge, or in cases where the occlusion makes it impossible to remove enough lingual enamel to allow for the proper thickness to make a jacket crown. This restoration is used also on teeth which need a jacket crown but are exceptionally thin labiolingually. It is easily adaptable for the establishment of a positive lingual rest seat on an anterior tooth for an indirect retainer of a partial denture.

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FILLING UNDERCUTS ON REFRACTORY CASTS WITH INVESTMENT

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THERE is no partial denture refractory cast more accurate than one made by pouring investment into a hydrocolloid impression taken directly from the mouth. To eliminate unwanted undercuts on such a refractory cast, drill cavities into the dry investment in the undercut areas with a bur so that rough locks for fillers

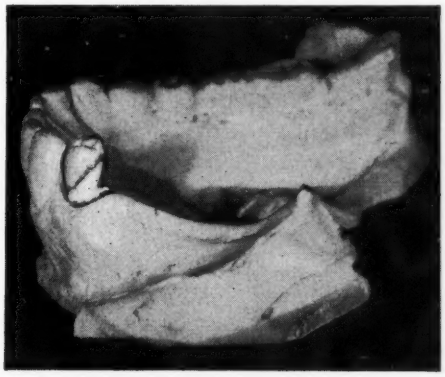

Fig. 1.—Survey marks outline the undercut.

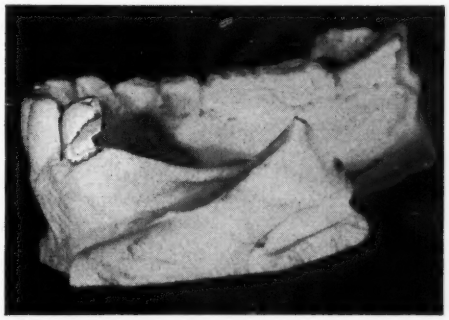

Fig. 2.—The cavity is cut and ready for the addition of fresh investment.

are provided (Figs. 1, 2). Then soak the cast in water for a few minutes, or, if in a hurry to get on with waxing against a dry cast, fill the newly cut holes a few times with water from a medicine dropper. Next paint and pat a fresh mix

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of investment into these retention holes until the undercut areas are filled and smooth (Fig. 3). Final shaping can wait until the added investment is hard. Avoid thin overlaps of the new investment over the old by bringing the margins of the cuts even with survey lines. A very accurate casting will result. When a

Fig. 3.—The undercut is filled.

stone cast is wanted for use in the laboratory, a second hydrocolloid impression can be made of the mouth. The stone cast and the refractory cast should be identical except for unimportant soft tissue deflections around the margins. The casting can be accurately fitted on this second cast before taking it to the patient.

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COMPENSATION BY THERMAL EXPANSION

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THERMAL expansion of a mold made of high thermal expanding investment can be shown to provide the most accurate of the several means for compensating casting variables.

COMPARISON OF METHODS OF COMPENSATION

1. *Wax Expansion.*—Wax is the most variable of the materials used for inlay construction. Its high rate of thermal expansion made wax expansion a popular method of compensation in the nineteen twenties before the advent of high thermal expanding investments. The tendency for wax to warp at higher temperatures makes this method inaccurate. However, any change in size of a wax pattern from mouth or fabrication temperature to investing temperature must be compensated for accurate end results.

2. *Setting Expansion.*—All present investments expand somewhat while setting, compensating partially for gold shrinkage.

3. *Hygroscopic Expansion.*—Present-day investments manifest a widely varying degree of additional expansive power when allowed to take up additional water while setting. This property, first described by Scheu[1,2,3] in 1932, is the principal means for compensation in the so-called hygroscopic techniques.

Phillips,[4] Skinner,[5] and others have shown that strains within the pattern cause the pattern to warp rapidly at temperatures approaching the softening point. Yet a pattern in other than a completely softened state tends to *resist* compensation by *setting* and *hygroscopic* expansion means. Smyd[6] has shown that a distorted mold results from the resistance of a wax pattern to both setting and hygroscopic expansion. He has explained the type of warped casting which plagues the hygroscopic technique. Only by using a soft pattern wax was he able to eliminate distortion from this source in the so-called hygroscopic technique. Soft pattern waxes are impractical for clinical use.

A further problem results from the fact that different batches of hygroscopic investment vary in expansive power. In fact, a given batch will gradually lose expansive power after the can is opened. For best results, extreme care must be taken to prevent the investment from changing its water content after the can is unsealed. This necessitates immediate closing of the can and keeping it closed after using a portion.

Read before the Dental Materials Group of the International Association for Dental Research, Colorado Springs, Colo., March 23, 1952.

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4. *Thermal Expansion* takes place in the inlay oven as the temperature of the mold is raised. This expansion swells the completely set mold in every direction. The force is adequate enough to overcome the slight resistance of the wax, and of a *loosely* placed asbestos lining in the ring, as heat is applied. Thermal expansion is thus the most accurate means known for compensation. Thermal expansion *alone* cannot be had, however, because all present dental investments expand slightly while setting, which is an inevitable source of some distortion.

Docking[7] has reported that many investments exhibit some degree of hygroscopic expansion, resulting from contact with the asbestos liner which is necessary to allow for mold expansion within a metal inlay ring. Docking has shown that whether the asbestos is moistened or not makes little difference in the amount of hygroscopic expansion. Even if the investment is poured into a ring lined with dry asbestos, enough water soaks out into the lining to later create some hygroscopic expansion. A determined attempt was made by the author to deprive the investment of any possible source of extra water. First the asbestos liner was covered with waxed paper and wax. This was found *not* to be dependable because of occasional leakage. Next, soft rubber inlay rings of 1 inch and 1½ inch diameters were tried with the thought that they would yield to setting expansion without furnishing a water supply for hygroscopic expansion. The investment mold when set was removed from the rubber ring before it was placed into the furnace. Cristobalite molds invariably split even when protected by wrapping with a turn of dry asbestos and slipped into a split metal ring. Cristobalite investment and Cristobalite control powder mixtures were stronger but they also cracked causing fins on the casting. Ransom and Randolph gray investment molds did not crack because the material is very strong at higher temperatures. Because of this strength its resistance to gold shrinkage tends to cause another kind of distortion. However, investments containing Cristobalite are the only ones having sufficient thermal expansion to compensate for casting variables without additional hygroscopic and/or wax expansion.

Present efforts to eliminate hygroscopic expansion from an investing technique have not been successful. The metal ring with a loose asbestos liner has been accepted as necessary even though it causes some hygroscopic expansion with its resultant distortion.

Smoother casting surfaces result from the thicker investment mixes made possible by vacuum investing. Low heat burn-out from 700 to 900°F. produces a smoother mold than is possible with a higher temperature burn-out. These factors should be incorporated into the ideal casting technique.

Based upon these facts and deductions the following investing and casting technique is proposed:

TECHNIQUE

1. Indirect patterns should be made at an open-mouth temperature of 95°F. the same as direct patterns. Smyd has suggested that indirect patterns be waxed over the warmth of an electric heating pad or under electric lamps in reflectors close over a bench. The temperature of the area above the heating pad can be checked by a thermometer. Otherwise the fabrication temperature is never known, and

accurate compensation is impossible with indirect techniques. One investing technique can thus serve equally well for both direct and indirect methods. The wax can either be melted, poured into the cast, and then compressed, or be kept in a wax annealing oven at 120°F. ready for molding. Phillips[8] has shown that waxes so prepared carry the least strains and so warp the least. The pattern should be mounted on a large sprue-former long enough to place the pattern within ¼ inch of the end of the ring (with thick mixes of investment this aids in escape of air from the mold). A utility wax ball should be formed on the sprue pin close to the pattern, to serve as a reservoir. The reservoir can be continuous with the crucible former and it should be larger than the inlay. As the gold of the inlay congeals and shrinks, molten gold from the reservoir will feed through the large short sprue into the inlay. Shrinkage porosity thus will occur in the reservoir rather than in the dental casting.

2. Patterns should be invested immediately, or else be kept in the freezing compartment of a refrigerator[9]. The pattern is scrubbed with hydrogen peroxide to remove possible organic matter and with 10 percent aerosol or commercial pattern cleaner to remove oil and to lower surface tension. Rinse and *dry*. (Skinner[10] has listed water on the surface of a pattern as one of several causes of rough castings.)

3. Investments were chosen which had the least tendency to hygroscopic expansion. Seven grams of Cristobalite investment and 14 Gm. of Ransom and Randolph gray investment are mixed together. This 21 Gm. of the combined powders is mixed with 6½ c.c. of room temperature water, (a water-powder ratio of 0.31) by the vacuum mixing and investing technique, using a moist asbestos lined metal ring sealed to the crucible-former base. This mixture of investments gives some of the advantages of both. A clean bright casting is obtained which is typical of the Ransom Randolph investment and impossible with Cristobalite alone. It is balanced for complete compensation with the technique outlined. However, the degree of expansion can be changed by increasing or decreasing the Cristobalite ratio. Cristobalite investment expands sufficiently to allow a desirable low-heat (900°F.) burnout. The combined investments makes a strong mold, yet not so strong as to harmfully resist gold shrinkage.

4. The invested pattern is set into a 100° F. water bath with the water not over the tops of the rings, or with a section of rubber tubing slipped over each ring top to keep water from contacting the investment. (Keeping additional water from the investment gives the *minimum* possible amount of hygroscopic expansion.) The 100° F. water bath returns the wax pattern to the approximate temperature at which the wax stopped flowing. Therefore, the size at which it was made does not raise it high enough to produce appreciable warping.[11] The slow-setting investment combination allows ample time for the pattern to regain its original temperature and its original size. Allow it to set forty-five minutes or more in the water bath.

5. Then evacuate the wax from the mold by boiling in a pan of water for two minutes and applying suction or centrifuge.

6. Raise temperature of the mold slowly to 900°F. for over a period of one hour, starting with a cool oven. Hold the temperature at 900° F. for ten or more minutes which brings the entire mold to an even temperature.

7. Cast quickly into the hot mold. Quench the mold in water for easy removal of the investment.

8. Heat the casting to a cherry red and quench in hydrochloric acid. Heat again and quench in 70 per cent alcohol[12] to remove completely all harmful acid residue before cementation.

9. Mask the margins and outer surface of the inlay with wax and etch the cavo-surface with aqua-regia to allow room for cement to flow from under the completely seated inlay.[13]

The results of this technique could be improved by development of an investment having neither setting nor hygroscopic expansion, or less of each. Docking[14] has shown Cristobalite investment to have a combined setting and hygroscopic expansion of 0.58 per cent where an asbestos liner is used in the ring. This is approximately one-half per cent, as compared to the 2 per cent plus expansion of the so-called hygroscopic investments and their resultant warpage of complicated castings.

This technique will consistently produce castings to fit the critical Bureau of Standards type mesio-disto-occlusal die. Clinical results surpass those of any other known technique.

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THE HYGROSCOPIC SETTING EXPANSION OF A DENTAL CASTING INVESTMENT

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IN the last twenty years, there has been considerable research done in order to determine a method which will compensate for the shrinkage that takes place when casting gold alloys change from the liquid to the solid state. In order to obtain such compensation, hygroscopic expansion has been used for a number of years since Scheu[1] worked on the possibility of using this method to compensate for the gold shrinkage.

This study was undertaken to determine if as high a hygroscopic expansion of investment was obtained when using a water bath at room temperature, as compared to a water bath at mouth temperature. It was also intended to see if the manipulation of the investment by hand or mechanically affects the amount of hygroscopic setting expansion to any appreciable degree. A comparative study of measurement methods for hygroscopic setting expansion was made in order to verify which one would offer greater accuracy of results.

Compensation of gold alloy shrinkage when it is cast was obtained by techniques which depended on the thermal expansion of the wax and of the investment, until a new technique was presented by Scheu[1] in 1932, which utilized the setting expansion of the investment. Scheu discovered that if the investment mixture was placed in water after initial set, it would expand sufficiently to compensate for the gold shrinkage. According to this author: " . . . an expansion of from 1.5 per cent to 1.6 per cent seemed to be proper."

Scheu found that (1) the thicker the mix, the greater the expansion. (2) A mix made with hot water expanded more than one made with cold water. (3) The time at which the mix is placed in the water is of great importance. (4) If the mix was placed in the water early, it would not expand as much as when placed in a little later after initial set. (5) The investment should remain in the water at least twenty minutes and no more than thirty minutes. Scheu[2] also found that (6) each investment has a definite amount of expansion when mixed, using the same water/powder ratio. (7) The temperature of the water, in which the investment ring is placed, slightly controls the expansion. (8) Water at a temperature of 100° F. slightly softens the wax pattern, so that the fine margins in the investment are not marred while expansion is taking place.

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Hollenback[3] presented an outline of Scheu's technique, whereby it became possible for any dentist to make a gold inlay using the hygroscopic setting expansion of an inlay investment. In this paper he said that a mechanical spatulator is to be recommended although hand spatulation will do fairly well.

Scheu[4] suggested that if the investment be put in contact with moisture for thirty minutes while setting, there is as much as 3 per cent expansion. The water must be at 105° F. to 110° F. in order to prevent the influence of the wax on the investment expansion. On the other hand, the water at that temperature will soften the wax pattern preventing the investment from being marred.

Degni[5] concluded that (1) since the hygroscopic expansion is very sensitive to confinement of any type whether it be pressure or friction, it is impossible to establish its absolute value. (2) The lower the temperature of the water bath, the lower the hygroscopic expansion.

Docking[6] observed that it does not make much difference if the bath is maintained at 37° C. or if the bath is allowed to cool below 37° C. This author gives great importance to the time at which the mix is immersed in water, the same point which Scheu made previously. Docking[7] suggested further that higher expansion is obtained when the mix is put in the water as soon as possible after mixing. He found[8] that the use of wet or dry asbestos gave almost the same amount of hygroscopic expansion. Slightly less expansion was obtained when dry asbestos was used.

Landgren and Peyton[9] concluded: (1) Hygroscopic expansion decreases with increased time between mixing and immersion when immersion is made after initial set. (2) Greater expansion is obtained, and the results are most uniform when the investment is immersed before initial set. (3) Higher temperature of the bath gives increased expansion when the investment is immersed after initial set.

METHOD OF MEASUREMENT AND MATERIALS

Because it was desired to study the hygroscopic setting expansion of an investment under conditions most nearly approaching those occurring in dental practice, the dial gauge method of Degni and Docking's modification were chosen. In both methods the investment is placed into a ring with asbestos liner, and placed in a water bath. The main difference between the two methods is that in the first one, a dial gauge is placed in contact with the investment by means of a microscope cover slide, and in the second method the measurement is obtained without contact with the mass of investment.

In the Degni method, the samples of freshly mixed investment were placed in a casting ring with an asbestos lining. A weighed quantity of investment was added to a measured amount of distilled water at room temperature in the mixing bowl which was damp dry. The time of spatulation was fifteen seconds when it was made by hand, and 105 turns of the spatula when a mechanical mixer was used. In all cases, after spatulation, the mix was poured, under vibration, into the casting ring lined with wet asbestos which had a length sufficient to cover all the inside diameter of the ring. The width was 1 3/4 in. and the thickness

1/32 in. On top of the ring, a square microscope cover slide was placed with a length 1/8 in. shorter than the diameter of the ring.

Specimens were placed in a water bath at both room temperature and mouth temperature, which was kept at 37°C. ±0.5°C. by using a thermostatically controlled pan. The temperature in both cases was observed by a thermometer placed in the water bath with its mercury bulb as near the ring as possible.

The expansion was measured by the dial gauge micrometer placed in contact with the microscope cover slide on top of the specimen. Each point of the dial gauge had a value of 1/1000 in. A description of the equipment has been given in a previous report from this laboratory.[9] In order to reduce the pressure of the dial gauge on the specimen, it was counterbalanced with a thread attached to the top of the micrometer and passed over a pulley to which a weight of 68.5 grains was tied in the free end of the thread.

The test samples had an initial length of 1.49 in., and 1.25 in. diameter. All samples were immersed in water immediately after mixing. The initial set was determined by a Gillmore needle. Several water/powder ratios were used. In each experiment, readings were taken at one minute intervals in the first thirty minutes, and then at five minute intervals toward the end of the measurement period, which was between fifty and fifty-five minutes.

The investment used for these tests was acquired in the regular market, and was the Hygroscopic Investment made by the Ransom & Randolph Co., Toledo, Ohio. Care was taken to make tests on the same batch.

An adaptation of the principle used by Docking was used in the second series of experiments.[6-8] A measured weight of investment to a measured amount of distilled water at room temperature was used. Spatulation was made by means of a mechanical mixer using two conditions, 105 turns and 350 turns of its spatula.

On top of the ring, a wire 1½ in. long and about 90 microns in diameter was placed, with one of the ends bent to form a good attachment when embedded in the investment. The samples were made in an inlay ring of 40.6 mm. (1.6 inches) height and 30 mm. (1.18 inches) in diameter, lined with asbestos the same as for the Degni method.

Specimens were placed in a water bath at room temperature at 23°C. ±1°C. (73.5°F. ±1.9°F.) The expansion was measured by means of a screw micrometer microscope, the smallest division of measurement being 0.0008 mm. The displacement of the wire, as measured by the screw micrometer, was considered the expansion of the investment. Readings were taken at intervals as close as possible from the time the wire stopped sinking into the investment until thirty minutes after immersion of the sample. The same brand of investment was used as when the Degni method of measurement was employed. All samples were placed in water immediately after mixing.

EXPERIMENTAL DATA AND DISCUSSION

Using the dial micrometer method of measurement previously described,[5, 9] the total hygroscopic setting expansion was measured for sev-

TABLE I. AVERAGE OF RESULTS OBTAINED AND PERCENTAGE OF DEVIATION

METHOD OF MEASUREMENT	SPATULATION METHOD	TEMP. OF WATER BATH	WATER/POWDER RATIO											
			28/100			30/100			32/100			34/100		
			AVERAGE EXPANSION	MAXIMUM DEV. %		AVERAGE EXPANSION	MAXIMUM DEV. %		AVERAGE EXPANSION	MAXIMUM DEV. %		AVERAGE EXPANSION	MAXIMUM DEV. %	
				+	−		+	−		+	−		+	−
1 Degni	By hand	Room	2.17	9.2	8.2	1.88	6.3	4.2	1.98	8.0	7.0	1.93	3.6	3.1
2		Mouth	2.06	5.3	2.9	1.97	1.5	1.5	1.85	2.7	2.7	——		
3	Mechanical	Room	2.30	7.3	8.6	2.17	3.2	3.2	1.96	5.6	4.8	1.97	3.5	3.5
4		Mouth	2.06	9.7	5.9	1.96	5.1	5.1	1.84	2.1	2.1	——		
5 Docking		Room	2.27	1.3	1.3	2.25	3.5	3.5	2.10	1.9	3.7	2.03	0.9	5.4

eral water/powder ratios; water bath temperatures kept at both room and mouth temperatures; and spatulation done both by hand and mechanically. Results of these tests are given in Table I and in Fig. 1, which are the average of at least three values for each condition. The values represent the expansion obtained after thirty minutes from the start of the mix and are not the maximum obtainable expansion as was described by Landgren and Peyton.

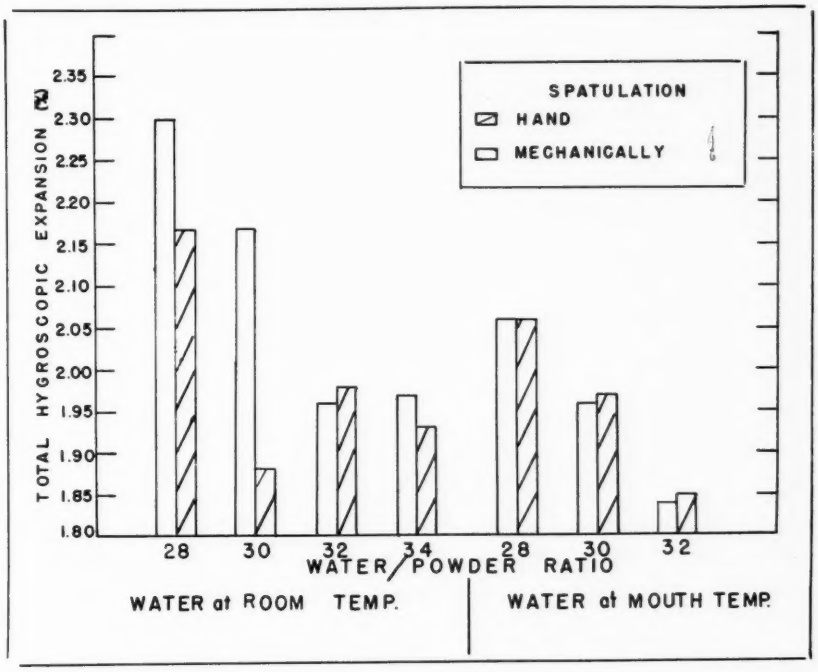

Fig. 1.

From these results it appears that mechanical spatulation gives higher expansion for thicker mixes where the water bath is at room temperature, but with the bath at mouth temperature there seems to be a negligible difference in expansion between the mechanical and hand spatulation methods. From this series of experiments, it cannot be concluded that the lower the water bath temperature, the lower is the hygroscopic expansion. Since slightly higher values were regularly obtained with the water bath at room temperature, it appears that the water bath temperature need not be held at mouth temperature to develop adequate expansion in the mass. From the practical standpoint, however, in producing inlay from wax patterns perhaps the main reason why the investment is placed in water at mouth temperature is to soften the wax pattern, and thereby preventing the fine margins from being marred or deformed during the setting process. A thermal expansion of the wax will also result from the mouth temperature bath.

The results presented in Fig. 2 represent values obtained when measurements were continued for fifty minutes from the start of the mix, and, using the dial micrometer method of measurement. The water bath was maintained at room

temperature (23° C. ±1° C.) and mechanical spatulation was employed. The test samples were immersed in the bath immediately after preparation and the initial set is indicated on the base of the graph when the first readings were taken.

As can be seen from Fig 2, the greatest expansion took place in the first twenty minutes from the start of the mix. It was considered by Degni from his studies that "the amount of expansion that takes place after thirty minutes is too slight to be considered." From the measurements presented in Fig. 2, the expansion obtained after fifty minutes of immersion amounts to approximately 0.1 per cent more than that obtained after thirty minutes of immersion.

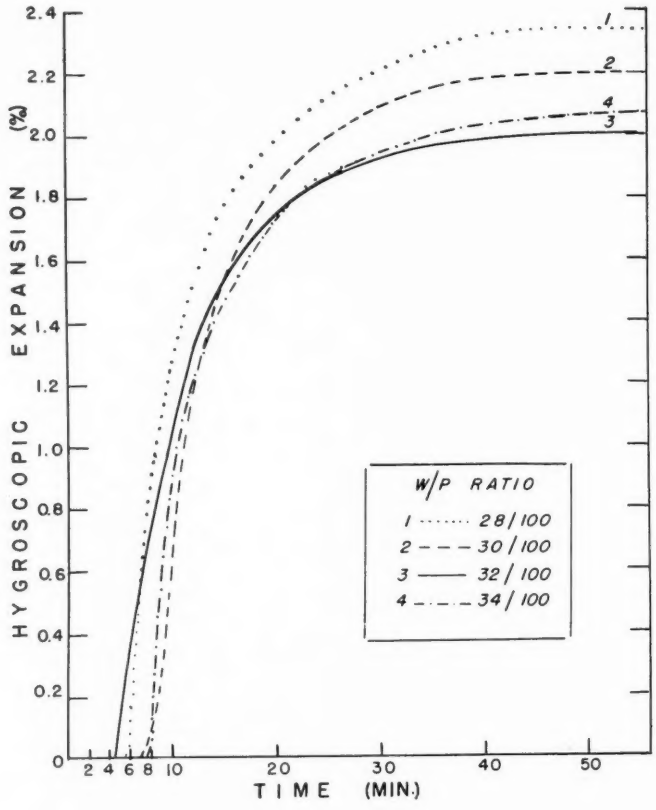

Fig. 2.

When the micrometer microscope method of measurement was employed it was observed that thicker mixes develop higher expansion as is shown in Fig. 3. By varying the water/powder ratio, different initial setting times were obtained as shown in Fig. 3, and the expansion varies with the initial setting time. The values represent those obtained from the use of mechanical spatulation and a water bath at room temperature. The results obtained from this method of measurement are similar to those obtained from the dial micrometer method, but in general are slightly higher by the micrometer microscope method for the same ratio.

The relation between the two methods of measurements and the effect of water/powder ratio is shown better in Fig. 4 which represents average values obtained when the two methods are compared, after thirty minutes of immersion in room temperature water. In comparing the average results obtained by both methods of measurements it is seen that only for the 28/100 ratio does the Degni, or dial micrometer method, show a higher expansion of 0.03 per cent than the micrometer microscope, or Docking method. From the values in Table I, it is seen also that the percentage variation in results was greater for the Degni method than the Docking method.

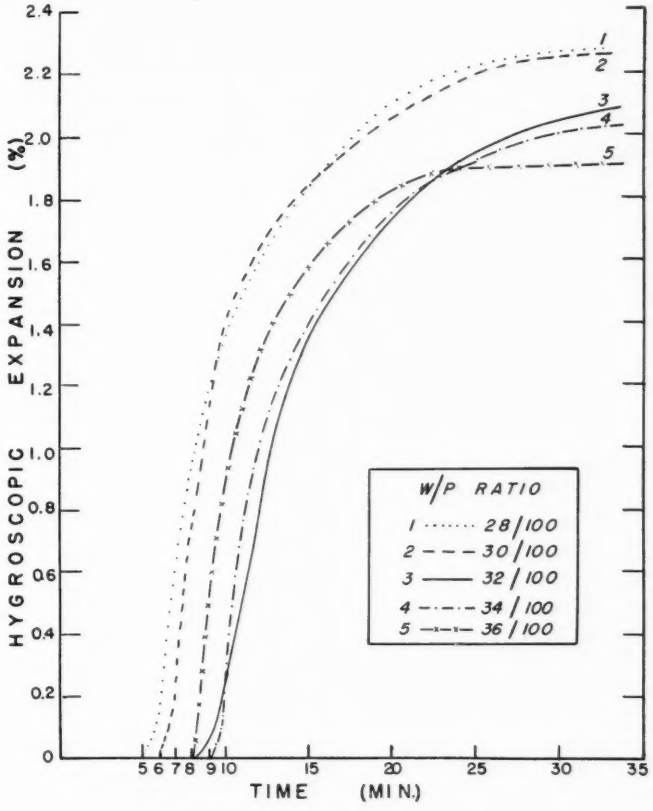

Fig. 3.

The results in Fig. 5 indicate the relation between the initial setting time in minutes and the hygroscopic expansion obtained after thirty minutes of immersion in room temperature water when both methods of measurement were employed. These curves represent also the relationship between the amount of expansion and the initial setting time as modified by changing the water/powder ratio. Mechanical mixing was employed for all samples using 105 turns of the spatula. Generally, higher values were obtained by the Docking method, with greater uniformity of results.

Since the expansion was higher with thick mixes which developed short setting times as a result of changing water/powder ratios, it seemed desirable to study the influence of a chemical retarder on the hygroscopic expansion values. For this purpose several concentrations of a borax solution were used with the investment powder in a 30/100 water/powder ratio. Mechanical spatulation was employed with the water bath at room temperature and the Docking, or optical micrometer, method of measurement of the hygroscopic expansion.

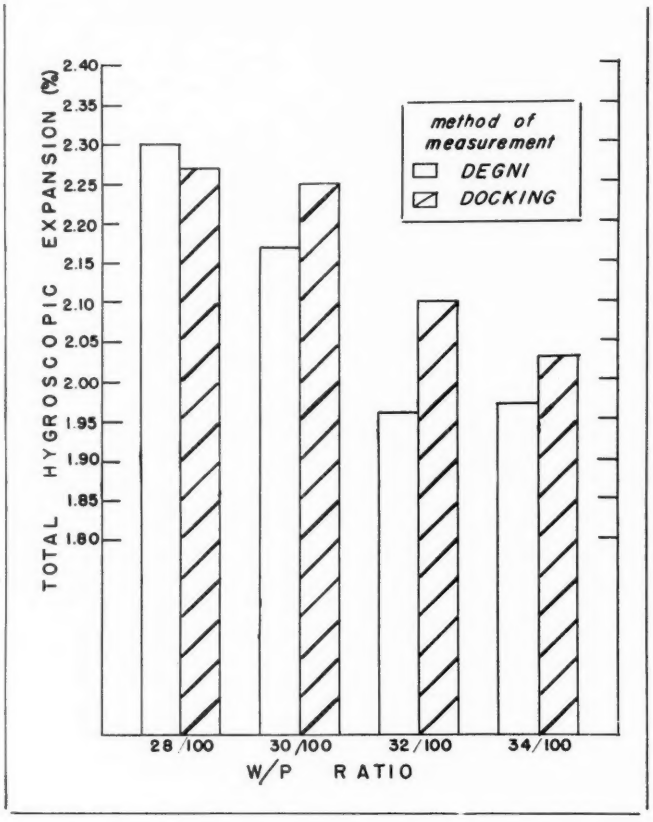

Fig. 4.

The results in Fig. 6 show the influence of borax solution in changing the setting time of the investment, as well as the change in expansion resulting from different borax solutions. It is observed that the higher the borax solution concentration the lower is the expansion. It is seen also that the longer the setting time, the lower is the expansion. No effort is made at this time to explain the mechanism of these changes in expansion or setting time and more study is indicated on this phase of the subject.

It is generally recognized that increased spatulation shortens the setting time of gypsum base materials. Some tests were made of the initial setting time and

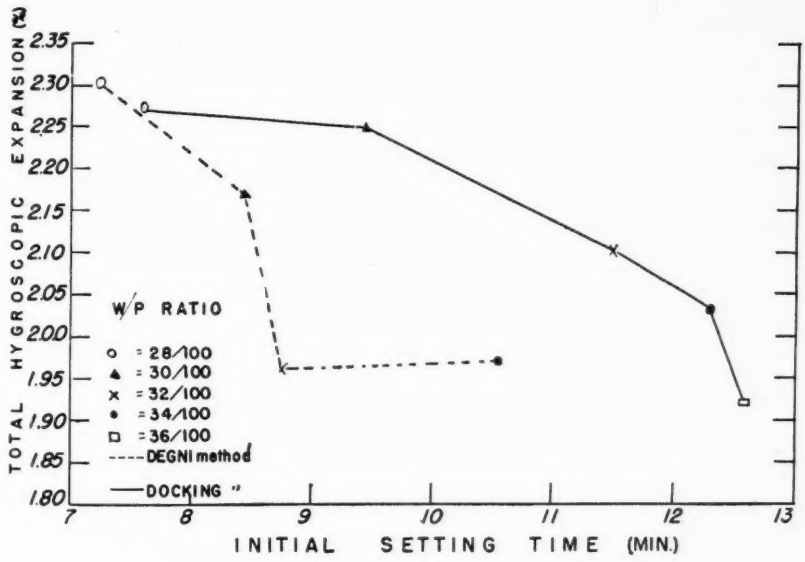
TOTAL HYGROSCOPIC EXPANSION (%)
2.35
2.30
2.25
2.20
2.15
2.10
2.05
2.00
1.95
1.90
1.85
1.80
W/P RATIO
○ = 28/100
▲ = 30/100
× = 32/100
● = 34/100
□ = 36/100
----DEGNI method
——DOCKING "
7
8
9
10
11
12
13
INITIAL SETTING TIME (MIN.)

Fig. 5.

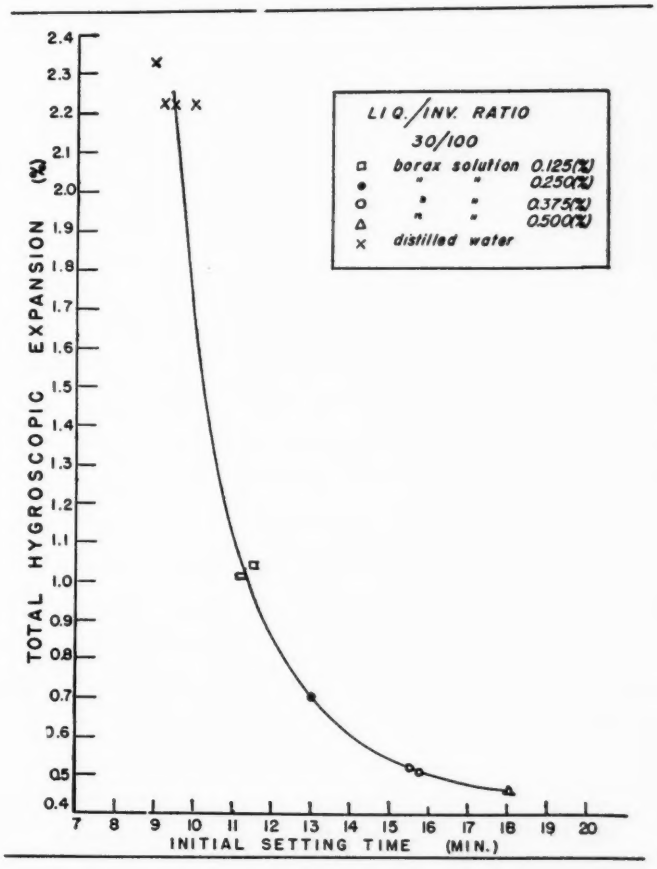
TOTAL HYGROSCOPIC EXPANSION (%)
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
LIQ./INV. RATIO
30/100
□ borax solution 0.125(%)
● " " 0.250(%)
○ " " 0.375(%)
△ " " 0.500(%)
× distilled water
7
8
9
10
11
12
13
14
15
16
17
18
19
20
INITIAL SETTING TIME (MIN.)

Fig. 6.

the expansion resulting from mixes made with different amounts of spatulation. The same water/powder ratio was used for both series of tests. Mechanical spatulation was employed and one series was made with 105 turns of the spatula while the other was made with 305 turns for each mix. The results are shown in Table II, which indicate that with 105 turns the average expansion was 2.25 per cent, and the initial setting time about nine minutes, while 2.72 per cent expansion resulted from 305 turns with the initial setting time about seven minutes. These results indicate that some correlation may exist between the initial setting time of the investment mass and the expansion which results. Further studies should be made to determine the significance of this apparent relationship.

TABLE II. EFFECT OF SPATULATION

SAMPLE	W/P RATIO	NUMBER SPATULA TURNS	INITIAL SETTING TIME MINUTES	PER CENT EXPANSION
1	30/100	105	9.5	2.22
2	30/100	105	9.0	2.23
3	30/100	105	10.0	2.22
4	30/100	105	9.0	2.33
				Average 2.25
1	30/100	305	7.0	2.71
2	30/100	305	6.5	2.66
3	30/100	305	6.5	2.74
4	30/100	305	7.0	2.78
				Average 2.72

CONCLUSIONS

1. The use of mechanical spatulation (105 turns of the spatula) or hand spatulation (fifteen seconds) does not affect the amount of hygroscopic setting expansion, when a water bath at mouth temperature is used.

2. Mechanical spatulation gives higher expansion values for thick mixes than hand spatulation, when a water bath at room temperature is used.

3. After thirty minutes of immersion there is a continued slight expansion which may be disregarded as being of little practical significance.

4. Under similar test conditions, higher expansion values are obtained when the water bath is at room temperature rather than at mouth temperature .

5. The dial micrometer method of measurement (Degni method) does not seem to be sensitive enough to indicate moderate differences in the manipulative technique.

6. The micrometer microscope method of measurement (Docking method) generally yields higher expansion values than the Degni method, with more consistent and reproducible results.

7. The addition of borax to the investment mix decreases the amount of expansion appreciably depending on the concentration.

8. Increased mechanical spatulation increases the amount of hygroscopic setting expansion.

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PHYSICS AND TECHNIQUES OF METAL INLAY LABORATORY PROCEDURES

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THE deflection and torsions set up in prosthetic structures by masticatory forces suggest that relatively large, complex, but thin "castings" are indicated when the castings serve as bridge or partial denture abutments. Such abutment castings are best made by indirect methods of inlay fabrication.

When metal dies are used to form the patterns of indirect inlays, castings are more uniformly accurate in summer than in the cooler seasons of the year. Dimensional instability of the wax pattern seems to be the most responsible element for inaccuracies which creep into the casting process.

In an effort to control the dimensional changes in patterns, room temperature came into focus for study. Even though the room temperature was thermostatically controlled twenty-four hours of the day, temperatures taken near the outside walls of the dental laboratory were found to drop as low as 55°F. in winter. During use, the laboratory temperature becomes greatly elevated. This fact introduces problems of stabilizing not only the pattern temperature but also the temperatures of the electroforming solution, room-temperature water, and supplies.

TEMPERATURE GRADIENT IN PATTERN FORMING

Pattern forming over metal is more difficult at 70°F. than at the laboratory temperature in summer time. For a considerable part of the summer season, the laboratory temperature may be 100°F. The waxing of patterns in a cool room is difficult because the die radiates heat from the warm wax. This chills the wax in contact with the die to room temperature, but the surface to which hot wax is applied is at a much higher temperature. Room temperature may be taken as 70°F., but melted inlay wax may be 350°F. A temperature gradient is thus established across the pattern when hot wax is added to a surface of the pattern. During the cooling of the hot wax, it congeals and shrinks and pulls the pattern away from the die. The edges of the pattern tend to pull or curl away from the margins. If the curled wax is forced into apposition with the die by finger pressure, the wax is strained and a pattern with elastic memory will result. These elastic strains will become manifest in a very short time as pattern distortions. Obviously the higher the melting temperature of the wax which is used for a given pattern, the greater the distortion will be.

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If the pattern is formed over a heated die, most of the significant strains can be avoided. Our aim should be to form a strainless pattern if possible. Marginal correction of the pattern is facilitated when pattern forming is done to warm dies. Molten wax flows readily to the warm die and can be retained passively in contact with the die if finger pressure is applied to the wax as it congeals. The more closely the die temperature approaches the melting temperature of the pattern wax, the freer the resulting pattern will be of strains.

PHYSICAL PROPERTIES OF PATTERN WAXES

A casting wax which melts at temperatures slightly above 110°F., which is plastic but yet rigid enough to hold a given form at temperatures slightly below 110°F. is best for indirect pattern forming. Such plastic wax is easy to work into inlay patterns when used in conjunction with the new die lubricants. It retains little strain, and by its plasticity offers very little restraint to expanding investment when the investment is going through its "gel" phase of setting.[1]

A working temperature of 110°F. is comfortable and relatively easy to maintain, winter or summer, with an electric heating pad. The dies, cast, lubricants, wax, and instruments are all placed upon the heating pad. When a thermometer placed on the pad registers 110°F., pattern forming can begin.

DIE MATERIALS

While hydrocal dies lack the toughness of metal dies and for this reason are often looked upon as inferior to metal they are superior to metal dies for pattern forming. Because of its cellular nature, hydrocal has poor thermal conductivity.

Table I shows the relative thermal conductance of materials familiar to the dentist. The thermal conductance of hydrocal is so low that it can be looked upon as a heat insulator. Even when impregnated with oil, since the thermal conductivity of oil is also very low, hydrocal dies are ideal for pattern forming. The great advantage of the small heat loss through the die shows up when hot wax is flowed directly to the die—the wax shrinks toward the die instead of away from it because the part which cools last is the part in contact with the die. This is just the reverse of waxing to a metal die.

Assuming that we start with an accurate hydrocal facsimile of the prepared tooth (the hydrocolloid techniques do make this possible), it is now possible to make a more accurate pattern by indirect than by direct methods. Whereas much elastic memory is retained in the direct pattern when the softened wax is changed from one configuration to another in adapting the wax to the cavity, all the wax strains are dissipated when the wax is *melted* into the cavity. Obviously the latter is not feasible for direct work; but when wax is melted into a hydrocal die, the shrinkage will be proportional because cooling does not occur across a significant temperature gradient and the pattern will be relatively free of strains.

Compressing, stretching, and rolling the wax are physical acts in the process of pattern forming which may not be avoided. When the patient bites upon the wax to adapt it to the cavity in direct pattern forming, he is compressing it. Since

TABLE I. THERMAL CONDUCTIVITY

Oil, petroleum @ 13°C.	0.000355
Oil, olive	0.000395
Water 4°C.	0.00138
Water 0°C.	0.00120
Water 17°C.	0.00131
Water 20°C.	0.00143
Air 0°C.	0.0000568
Plaster of Paris	0.00070
Glass	0.0018 - 0.0025
Gypsum	0.0031
Steel 100°C.	0.107
Aluminum 100°C.	0.492
Gold 100°C.	0.703
Copper 100°C.	0.908

Heat in cal/ sec/ 1 cm thick/ 1 cm² area/ °C.

wax is elastic, the direct pattern is deformed while in the cavity much as rubber can be squeezed into a container. When removed from the cavity, the pattern springs out. This accounts for the fact that direct inlays are tight in the cavity.

Since there is no point in compressing the wax melted into the hydrocal die, much elastic deformation of the pattern can be avoided. Furthermore, when working from a die, the technician may use softer waxes for pattern forming such as the tacky green casting wax sheets intended for partial denture casting purposes. The melting range of this wax is so close to the working range that thermal shrinkage and thermal gradient distortion of the pattern are negligible.

HYGROSCOPIC INVESTING

Library[2] and experimental research[3], and the author's experience over many years support the view that the hygroscopic method of mold expansion is most consistent in producing accurate castings. Hygroscopic investing is also desirable because it makes possible a year-round standardization of procedure without regard to room temperature and no variation of technique is required for the various inlay types. While it would seem inadvisable to mix two investments of differing expansion curves because of the difficulty of uniformly dispersing the two in the mixture, nevertheless the method is quite frequently employed with Cristobalite high-heat techniques. The investment of lower expansion is used more to prevent discoloration of the gold by the Cristobalite component than as a control over the expansibility of the Cristobalite.

PROCEDURE FOR PATTERN FORMING TO METAL DIES

Since pattern forming to hydrocal dies presents no special problem, only pattern forming to metal dies will be described.

The plastic wax used for the indirect inlay patterns is marketed under the name Kerr's *soft* green casting wax sheets. A sheet is doubled several times into a wad or stick and melted into the warmed (110°F.) inlay die with a hot wax spatula. Finger pressure should be maintained on the wax as it starts to harden in such a way that the pressure will hold the wax against the cavity margins. This is important because one may squeeze the wax away from the die by improper

thrust. Kerr's Microfilm is used on the die as a separating medium. After painting it on the die, a chip blower is used to blow off all but a microscopic film.

In the summer time a heavy deposit of the green wax may be overlaid with a thin veneer of regular inlay wax to facilitate carving, but usually the green wax is used alone.

After the carving of the pattern is completed, a slight trench, about one millimeter deep, is cut away from all the margins of the pattern. The trench is then filled with melted green inlay wax carried on a small wax carver. This corrects for the proportionately greater shrinkage of the original big mass of molten wax. The wax of the marginal correction is held to the die under finger pressure as it congeals. A slight surplus or skirt is left over all draftable margins. Wherever pattern extensions would prevent the free withdrawal of the pattern, the surplus should be trimmed right to the margin. Such margins should be thickened to provide gold for grinding-in and polishing[4].

A sprue is attached to a marginal ridge. Very soft plastic wax is daubed upon the upper surface of the sprue former to prevent the escape of soft investment from the lower edge of the inlay ring while the investment is standing. If it escapes, investment may pull away from the pattern. This is one of the causes of faulty castings if investments of low viscosity are used.

INVESTING PROCEDURE

The investing can be done at room temperature. Patterns can drop in temperature from 110° F. to room temperature if they are relatively strainless and *off* the die because wax shrinkage is proportional under these conditions. Since the pattern is placed into a water bath of 110°F. as soon as it is invested, the water bath quickly restores the temperature and dimension of the pattern to those at which the pattern was formed, and no figures for wax expansion or shrinkage need enter the equation for compensation. By test it was found that the temperature at the center of the ring was raised from 70° to 110°F. in about three minutes. The investment is still soft for a considerable time after this interval.

The pattern is painted with *pure* grain alcohol (96 per cent), to make it "receptive" to the investment, and permitted to air-dry. Alcohol is *not* a solvent of wax, if it is pure. While the pattern is drying, the usual preparation for investing is carried out. A loose coil of asbestos liner is placed in the casting ring and moistened; and the investment and water are accurately measured out, usually 50 Gm. of powder to 15 cc. of water. An investment intended for the hygroscopic technique should, of course, be used.

Hygroscopic investments tend to be viscous. After the pattern is carefully coated with investment, the lower edge of the inlay ring is imbedded into the very soft plastic wax on the base of the sprue former. The ring and base are now held together with the left hand and touched to the vibrating table of a mechanical vibrator while the investment in the bowl is permitted to run down the inner side of the inlay ring in a thin stream. As the ring gradually fills, the investment may be watched to see that no bubbles of air will be trapped upon the pattern. When the ring is full, it is immediately placed into a pan of water at 110°F.

An alternate method of filling the ring is to tease the investment from the bowl into the ring with the camel's hair brush used to apply investment to the pattern.

The invesmtent is gently pushed ahead of the brush into the space between the investment-coated pattern and the coil of asbestos. This method avoids the use of vibration which some technicians claim causes air bubbles to rise from the investment and cling to the pattern thereby giving rise to nodules in the casting.

The method here described has been used successfully in this form for many years. In recent years the method has been refined to include deaeration of the investment by means of vacuum, but the process is essentially the same.

The ring should be completely submerged in the water, and the pan should be placed where it will not cool off too rapidly. It is not necessary to keep the temperature constant. In the ensuing one-half hour, it will probably fall off 20°F. or more, but this is all right.

After the half hour in the water bath, the investment is ready for the burn-out. While it is common practice to defer the burn-out and casting until the following day or for longer periods, the most accurate castings are obtained if the burn-out and casting procedure follow an hour or two after investing. If casting has to be deferred to another day, the fresh investments, while still moist, should be placed in a humidor.

In practice, inlay investments are generally pooled and all are transferred at one time from the humidor to a cold oven. An oven temperature of 600 to 800°F. is maintained for about one and one-half hours if a gas oven is used. If an electric oven is used, 600 to 800° F. for thirty minutes is enough. The electric oven oxidizes the carbon from the wax much more rapidly than gas. The mold is now ready for casting.

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Jennings Hospital
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KEEP YOUR BUNSEN BURNER CLEAR

CLARENCE H. BLANCHARD, B.S., D.D.S.

Los Angeles, Calif.

DOES WAX clog your bunsen flame? If so — try this —
Make a guard from any convenient scrap of metal such as a tin can or a bit of brass to keep wax drippings away from the lumen of your bunsen burner. Do not use aluminum, since it would melt in the flame. The guard may be bent in

Fig. 1.—A metal blank is cut as shown. The bottom wings will make a collar to fit the burner tube, while the forward inclination of the baffle segment is used to engage the rim of the tube and prevent slippage downward.

various ways to give different shapes to the flame, but a fan-shaped flame is handy for annealing lengths of wire or for warming sheet wax. It is equally useful for heating spatulas, etc. Construction details are portrayed in Fig. 1. Such a guard will last for years.

617 S. OLIVE ST.
LOS ANGELES, CALIF.

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Reader's Round Table

San Francisco, Calif.

Editor, The Journal of Prosthetic Dentistry,

In reference to your comments (J. PROS. DEN. **3**:2, 1953) concerning my article "Preparation of the Mouth and Casts for Immediate Dentures" (J. PROS. DEN. **3**:66, 1953) I wish to thank you for your most generous evaluation of the script.

Your statement that surgery removal of large tuberosities might be done better and with more satisfactory results *before* the immediate denture is started has been confirmed in my article. Please refer to line 1, page 73, which reads "As this operation is usually accomplished before the master impression is made, no preparation is necessary on the cast" and to line 12, "This insufficiency of clearance should be corrected at the same time that the posterior teeth are removed."

As to Torus Mandibularis or Lingualis, in my opinion, the removal of these abnormalities is best accomplished at the time of the insertion of the immediate denture. The thinness of the mucosa, the difficulties of suture, and the matrix-like action of the denture base aids in the recovery of the tissue by protecting these surgical areas. The tongue manipulations and food injuries which are due to the heavy traffic in this area are sufficiently protected by the denture base. This aids in maintaining the blood clot and keeping the tissue in proximity which in turn promotes healing. Of all the operations in the mouth this one, to my knowledge, is the most difficult to expedite healing without the protection of an immediate denture. The denture is also an aid in maintainng medicaments such as the antibiotics, hemorrhage control drugs, and analgesics.

Trusting that these remarks will be received by you in the spirit of cooperation to better denture service. I remain.

Yours very truly,

WILLIAM G. MAISON, D.D.S.

News and Notes

ANNOUNCEMENTS

The American Academy of Implant Dentures will meet in Cleveland, Ohio, in the Allerton Hotel on Sept. 27, 1953. For reservations, write to Dr. William E. Barb, 668 E. Maple Road, Indianapolis, Ind. For further information, write to Dr. M. W. Mueller, 1172 Lowry Medical Arts Bldg., St. Paul, Minn.

Georgetown University School of Dentistry, Washington 7, D. C., announces the following Postgraduate Course No. 57: "Advanced Procedures in Crown and Bridge," five days (Monday through Friday). Course starts June 1, 1953, and ends June 5, 1953.

The Indiana University School of Dentistry announces a one week postgraduate course in Crown and Bridge Prosthesis, Oct. 19 to 23, 1953. For further information write to Dean Maynard K. Hine, Indiana University School of Dentistry, 1121 W. Michigan St., Indianapolis, Ind.

The New York University College of Dentistry announces postgraduate training in Practice Management to be offered June 8 to 12, 1953, 1 to 4 P.M. and 6 to 9 P.M.

The Periodontia Department of New York University College of Dentistry announces postgraduate courses in Periodontia and Oral Medicine under the supervision of Dr. Samuel Charles Miller. These are full time for one academic year, Sept. 21, 1953, to May 21, 1954, half-time for two years, three weeks refresher courses, and ten sessions (one evening weekly) introductory courses.

For further information concerning these courses write to the Secretary, Postgraduate Division, New York University College of Dentistry, 209 East 23rd Street, New York 10, N.Y.

The next Greater New York Dental Meeting will be held at the Hotel Statler, Dec. 7, 8, 9, 10, and 11, 1953.

The 1953 annual meeting of the American Denture Society will be held Friday and Saturday, September 25 and 26, at the Hollenden Hotel in Cleveland. Members should make their hotel reservations at once on the blanks furnished by the American Denture Society.